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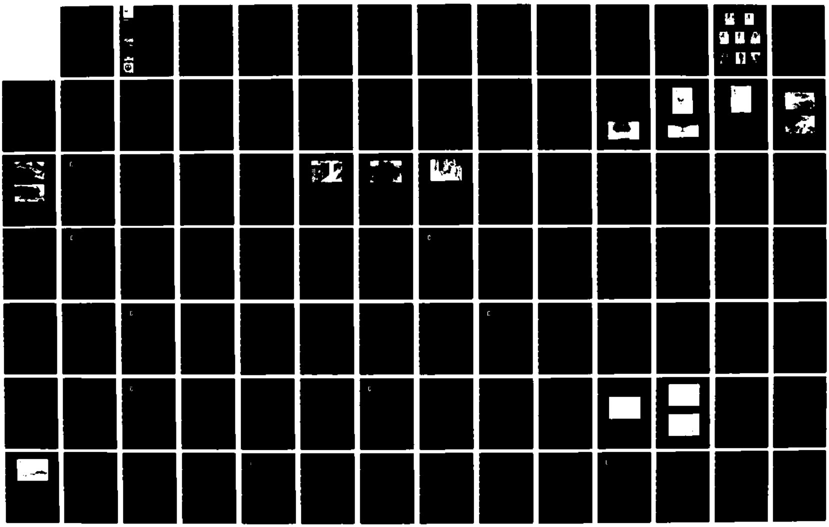

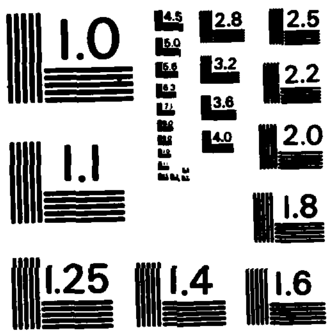

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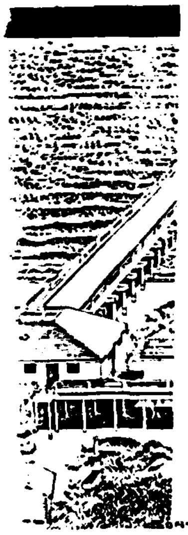
US Army Corps of Engineers

PROCEEDINGS OF THE 43RD MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

22-24 May 1985

VICKSBURG, MISSISSIPPI

Hosted by
US Army Engineer Waterways Experiment Station
Coastal Engineering Research Center



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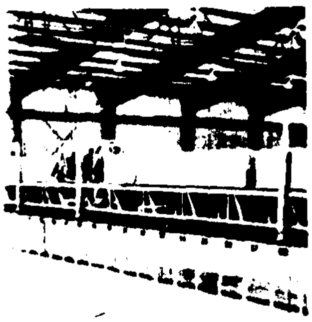

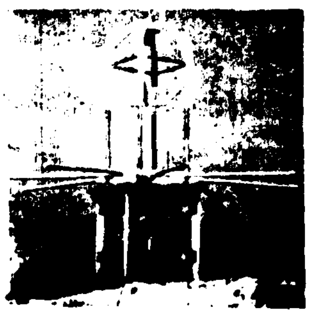

August 1985

Final Report

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Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Published by The Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631

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A159991

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A159991	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PROCEEDINGS OF THE 43RD MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD; 22-24 May 1985; VICKSBURG, MISSISSIPPI		5. TYPE OF REPORT & PERIOD COVERED Final report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert W. Whalin, Editor		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Waterways Experiment Station Coastal Engineering Research Center PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Coastal Engineering Research Board
11. CONTROLLING OFFICE NAME AND ADDRESS DEPARTMENT OF THE ARMY US Army Corps of Engineers Washington, DC 20314-1000		12. REPORT DATE August 1985
		13. NUMBER OF PAGES 494
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Coastal engineering--Congresses (LC)
Coastal Engineering Research Board (WES)
Shore protection (LC)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

These proceedings provide a record of the papers presented at the 3-day semiannual meeting of the Coastal Engineering Research Board (CERB). Also included are the following: (1) discussions of CERB business, the paper presentations, and the tour of CERC's experimental facilities; (2) comments about and recommendations for research and development by CERB members; and (3) responses to research needs of Corps Districts and Divisions by the Coastal Engineering Research Center.

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PREFACE

The Proceedings of the 43rd Meeting of the Coastal Engineering Research Board (CERB) were prepared for the Office, Chief of Engineers (OCE), by the Coastal Engineering Research Center (CERC), of the US Army Engineer Waterways Experiment Station (WES). They provide a record of the papers presented, the questions and comments in response to them, the interaction among program participants and the CERB, and the tour of CERC's facilities.

The meeting was hosted by WES under the direction of COL Robert C. Lee, Commander. Mr. C. E. Chatham, Jr. is to be commended for organizing the field trip and Messrs. D. D. Davidson and Douglas G. Outlaw for conducting the tours. Acknowledgments are extended to the following: Mr. Stephen E. Wagner for his assistance in setting up the meeting and operating the video equipment; Mr. Robert Hall for his assistance with the audio equipment; Miss Carol L. Horn for her assistance at the meeting; Mrs. Betty M. Dorman along with Messrs. Richard E. Smith and Jonathan E. Warwick for their photography and videotaping assistance; and Ms. Elizabeth J. Brady, Court Reporter, for taking verbatim dictation of the meeting. Worthy of commendation also are Mrs. Harriet L. Hendrix and Mrs. Sharon L. Hanks (CERC/WES) whose assistance in setting up the meeting and assembling information for this publication proved invaluable, and Mrs. Shirley A. J. Hanshaw (Publications and Graphic Arts Division/WES) who designed the format, edited, and compiled these proceedings.

Members of the CERB--BG C. E. Edgar III, CE, BG George R. Robertson, CE, BG Donald J. Palladino, CE, Dr. Bernard J. Le Méhauté, and Professor Robert L. Wiegel--participated actively in all discussions and provided many thoughtful and instructive comments.

The proceedings were reviewed and edited for technical accuracy by Dr. Robert W. Whalin, former Chief, CERC, Mr. Charles C. Calhoun, Acting Chief, CERC, and Dr. James R. Houston, Chief, Research Division, CERC. COL Robert C. Lee, CE, Executive Secretary of the Board and Commander and Director, WES, provided additional review.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

C. E. Edgar III
C. E. Edgar III
Brigadier General, Corps of Engineers
President, Coastal Engineering Research Board

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CONTENTS (Continued)

CONTENTS (Continued)

THURSDAY, 23 MAY, AFTERNOON SESSION

CONTENTS (Concluded)

INTRODUCTION

The 43rd Meeting of the Coastal Engineering Research Board (CERB) was held at the Magnolia-Best Western Hotel in Vicksburg, Mississippi, on 22-24 May 1985. It was hosted by the US Army Engineer Waterways Experiment Station (WES), under the direction of COL Robert C. Lee, Commander and Director. The program format was designed to promote information exchange among members of the Board and attendees from various US Army Corps of Engineers (Corps) Districts and Divisions and the Office of the Chief of Engineers.

The Beach Erosion Board (BEB), forerunner of the CERB, was formed by the Corps in 1930 to study beach erosion problems. In 1963, Public Law 88-172 dissolved the BEB by establishing the CERB as advisory board to the Corps and designating a new organization, the Coastal Engineering Research Center (CERC), as the research arm of the CERB. The CERB functions to review programs relating to coastal engineering research and development and to recommend areas for particular emphasis or suggest new topics for study. The Board's four military and three civilian members meet twice a year at a particular coastal Corps District or Division to do the following:

(1) Disseminate information of general interest to Corps coastal Districts and Divisions.

(2) Obtain reports on coastal engineering projects in the host (local) District or Division; receive requests for research needs.

(3) Provide an opportunity for State and private institutions and organizations to report on local coastal research needs, coastal studies, and new coastal engineering techniques.

(4) Provide a general forum for public inquiry.

(5) Provide recommendations for coastal engineering research and development.

The primary focus of the 43rd CERB meeting was CERC, which was relocated from Fort Belvoir to WES in 1983. Paper presentations dealt mainly with various coastal studies under way at CERC and four work units in the Coastal Engineering Area (narrative rationales and spreadsheets in Appendix E). In addition to the papers on research efforts at CERC, a presentation was made on current and future expansion of CERC's physical plant, and a tour was conducted of CERC's experimental facilities. In response to a request made at the 42nd CERB meeting, a presentation on the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Program was given. REMR is divided into seven

Problem Areas, one of which is Coastal. To put the work of CERC into perspective, members of the Senior Executive Service from the Office of the Chief of Engineers and the Water Resources Support Center made presentations on coastal engineering responsibilities of various Corps functional elements including programs, hydraulics and hydrology, engineering and construction, operations and readiness, policy, water resources, research and development, planning, and dredging. The discussions which followed these presentations as well as recommendations by the Board for coastal engineering research and development are documented in these Proceedings.

THE COASTAL ENGINEERING RESEARCH BOARD
May 1985

BG C. E. Edgar III, President
Deputy Director of Civil Works
US Army Corps of Engineers
Washington, D. C. 20314

COL Robert C. Lee, Exec Sec
Commander and Director
US Army Engineer
Waterways Experiment Station
PO Box 631
Vicksburg, MS 39180

BG George R. Robertson
Commander
US Army Engineer Division,
North Pacific
PO Box 2870
Portland, Oregon 97208

BG Forrest T. Gay III
Commander
US Army Engineer Division,
South Atlantic
510 Title Building
30 Pryor Street, SW
Atlanta, Georgia 30303

BG Donald J. Palladino
Commander
US Army Engineer Division,
South Pacific
630 Sansome Street,
Room 1216
San Francisco, California 94111

Professor Robert L. Wiegel
Department of Civil Engineering
Room 412, O'Brien Hall
University of California
Berkeley, California 94720

Mr. Willard N. Bascom
Director, Southern California
Coastal Water Research
Project
646 West Pacific Coast
Highway
Long Beach, California 80806

Dr. Bernard J. Le Méhauté
Professor, Ocean Engineering
Division
Rosenstiel School of Marine
and Atmospheric Science
4600 Rickenbacker Causeway
Virginia Keys
Miami, Florida 33149

43RD COASTAL ENGINEERING RESEARCH BOARD MEETING
Magnolia-Best Western Hotel
Vicksburg, Mississippi
22-24 May 1985

ATTENDEES

BOARD MEMBERS (CERB)

BG C. E. Edgar III, President
BG George R. Robertson
BG Donald J. Palladino
Professor Robert L. Wiegel
Mr. Willard N. Bascom
Dr. Bernard J. Le Méhauté

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Mr. Lloyd A. Duscha
Mr. Cecil G. Goad
Mr. Vernon K. Hagen
Mr. John G. Housley
Mr. John G. Lockhart
Mr. Jesse A. Pfeiffer
Dr. William E. Roper
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Mr. J. Michael Kieslich, SWG

WATER RESOURCES SUPPORT CENTER (WRSC)

Mr. William R. Murden, Jr.

WATERWAYS EXPERIMENT STATION (WES)

COL Robert C. Lee
Dr. Robert W. Whalin
Mr. Charles C. Calhoun, Jr.
Mr. Michael J. Briggs
Mr. Robert A. Cole
Dr. Yen Hsi Chu
Mr. D. D. Davidson
Ms. Julie Dean
Mr. Scott L. Douglass
Mr. David B. Driver
Mrs. Sharon L. Hanks
Mrs. Shirley A. J. Hanshaw

ATTENDEES (CONCLUDED)

WATERWAYS EXPERIMENT STATION (CON'T)

Dr. John Harrison
Mr. J. Michael Hemsley
Mrs. Harriet L. Hendrix
Mr. Frank A. Herrmann, Jr.
Dr. James R. Houston
Mr. Gary L. Howell
Dr. Jon M. Hubertz
Dr. Steven A. Hughes
Dr. Nicholas C. Kraus
Mr. William F. McCleese
Mr. Dennis G. Markle
Dr. William F. Marcuson
Mr. Curtis Mason
Dr. Suzette K. May
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Mr. Thomas W. Richardson
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Dr. Roger T. Saucier
Mr. John M. Scanlon, Jr.
Mr. William C. Seabergh
Mr. Andre Z. Szuwalski
Dr. Edward F. Thompson
Dr. C. L. Vincent
Mr. Stephen E. Wagner
Dr. William L. Wood

VISITORS

Dr. Dag Nummedal
Dr. Vernon Behrhorst
Mr. Chang Hua Ji
Dr. Joseph N. Suhayda

COURT REPORTER

Ms. Elizabeth J. Brady

43RD MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

22-24 May 1985
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

AGENDA

22 May

8:30 - 8:35	Opening Remarks	BG C. E. Edgar III, OCE
8:35 - 8:45	Welcome to the Waterways Experiment Station	COL Robert C. Lee, WES
8:45 - 8:50	Announcements	Dr. Robert W. Whalin, WES
8:50 - 9:05	Review of CERB Business	COL Robert C. Lee, WES
9:05 - 9:35	REMR Orientation	Mr. William F. McCleese, WES
9:35 - 9:50	New CERB Issues	BG C. E. Edgar III, OCE
9:50 - 10:10	Coffee Break	

Coastal Engineering Responsibilities of Corps Functional Elements

10:10 - 10:25	Programs Division	Dr. Bory Steinberg, OCE
10:25 - 10:40	Hydraulics and Hydrology Division	Mr. Vernon K. Hagen, OCE
10:40 - 10:55	Directorate of Engineering and Construction	Mr. Lloyd A. Duscha, OCE
10:55 - 11:10	Operations and Readiness Division	Mr. Cecil G. Goad, OCE
11:10 - 11:25	Office of Policy	Mr. Donald B. Duncan, OCE
11:25 - 11:40	Water Resources Support Center	Mr. William R. Murden, Jr., WRSC
11:40 - 11:55	Directorate of Research and Development	Dr. William E. Roper, OCE
11:55 - 12:10	Planning Division	Dr. Lewis H. Blakey, OCE
12:10 - 1:10	Lunch	
1:10 - 1:40	Coastal Engineering Research Center	Dr. Robert W. Whalin, WES
1:40 - 2:30	Discussion and Plan of Action	BG C. E. Edgar III, OCE
2:30 - 2:50	Coffee Break	
2:50 - 4:00	Discussion and Plan of Action	BG C. E. Edgar III, OCE
4:00 - 4:45	Crescent City Dolos Project	
	Dolos Workshop	Dr. William L. Wood, WES
	Finite Element Modeling	Mr. Robert A. Cole, WES
	Field Measurements	Mr. Gary L. Howell, WES
4:45	Adjournment	

Tour of CERC's Experimental Facilities

23 May

8:00	Leave Hotel Enroute to WES	
8:15 - 8:40	San Pedro Breakwater Rehabilitation	
8:40 - 9:05	Cleveland Harbor Breakwater Rehabilitation	
9:05 - 9:30	Lake Pontchartrain Outfall Canal Study	
9:30 - 10:00	Mission Bay Breakwater Revision	
10:00 - 10:30	Coffee Break	
10:30 - 11:45	Los Angeles/Long Beach Harbors Model 11-ft Flume - Low-Crested Breakwater Studies 6-ft Flume - Breakwater Stability Studies Fisherman's Wharf Model Data Acquisition and Control Facility Noyo Harbor Model Directional Spectral Wave Generator 3-ft Flume - Wave Runup and Overtopping Study 1.5-ft Flume - Lab and Scale Effect in Movable Bed Modeling	
11:45 - 12:20	Coastal Field Data Collection Facility	Mr. Gary L. Howell, WES
12:20 - 12:30	Bus Transportation to Hotel	

AGENDA (concluded)

23 May (Con't)

12:30 - 1:30	Lunch	
1:30 - 1:35	Open Meeting (Conference Room)	BG C. E. Edgar III, OCE
1:35 - 1:50	Future Facilities Plan	Mr. Charles C. Calhoun, Jr., WES
1:50 - 2:10	Research Program for Directional Spectral Wave Generator	Dr. James R. Houston, WES
2:10 - 2:40	Coastal Flooding and Storm Protection	Dr. Steven A. Hughes, WES
2:40 - 3:00	Harbor Entrances and Coastal Channels	Dr. Jon M. Hubertz, WES
3:00 - 3:20	Coffee Break	
3:20 - 3:50	Shore Protection and Restoration	Dr. Suzette K. May, WES
3:50 - 4:20	Coastal Structures Evaluation and Design	Ms. Joan Pope, WES
4:20 - 4:35	DUCK '86 Experiment	Dr. Nicholas C. Kraus, WES
4:35 - 5:20	Coastal Field Data Collection and Monitoring Completed Coastal Projects	Dr. William L. Wood, WES Mr. J. Michael Hemsley, WES
5:20 - 5:45	LMVD Research Needs	Mr. H. E. Walker, LMVD Mr. Cecil W. Soileau, LMVD
5:45	Adjournment	

24 May

7:30 - 7:35	Open Meeting	BG C. E. Edgar III, OCE
7:35 - 7:40	Announcements	Dr. Robert W. Whalin, WES
7:40 - 7:50	Selection of Date and Place for Next Meeting	BG C. E. Edgar III, OCE
7:50 - 8:20	Discussion of Tour, Research Programs, and Facilities Plan	CERB
8:20 - 9:00	Recommendations by Members of the Board	CERB
9:00 - 9:30	Public Comment	
9:30	Adjournment	

OPENING REMARKS

BG C. E. Edgar III, President
Coastal Engineering Research Board
Deputy Director of Civil Works
Washington, D.C.

The forty-third meeting of the Coastal Engineering Research Board will please come to order. I wish to welcome all of our attendees to Vicksburg. A very special welcome is extended to our European traveler who has just returned from France. Bernie, welcome back. I am pleased to know you had a most professionally rewarding time and happy to note too that the food and drink in France and all over Europe is still good.

We're missing General Ted Gay this morning. He will not be with us because he is in the final countdown of the dedication of the Tennessee Tombigbee Waterway, which takes place starting next week and culminates 1 June in Columbus, Mississippi. He sends his best and regrets that he cannot be here.

We also will have General Don Palladino with us for only a short time, as he will be representing the Chief, along with General Bob Bunker, in, of all places, Honolulu, where the Western Governors' Association is having its annual meeting. They will be discussing problems having to do with the western states.

I would like to welcome our member-elect, Dr. Dag Nummedal, Professor of Geology, Louisiana State University. We're happy to have you here with us at this session, Dag. Also we are very pleased to have our senior civilian members of the Office, Chief of Engineers, staff who will be part of our program today.

This is the first time the Board has met in Vicksburg since the Coastal Engineering Research Center (CERC) moved from Fort Belvoir. While many of us who are on the Board have been here individually and perhaps have gone through the facilities at one time or another since that move, this is the first time we have met collectively; and I think it is good for us to do that. There are a number of things that are now on line at CERC that were not during my last visit, and I think we're all very pleased to be here to see the new facility and to meet with the folks who comprise CERC.

WELCOME TO US ARMY ENGINEER WATERWAYS EXPERIMENT STATION (WES)

COL Robert C. Lee, Executive Secretary
Coastal Engineering Research Board
Commander and Director, WES
Vicksburg, Mississippi

Welcome to the Waterways Experiment Station (WES). I'm going to give you a 2-hr presentation in 10 min. As you know, five of the eight world-class laboratories that the Corps of Engineers (Corps) has are located here in Vicksburg. We started after the 1927 flood as a small hydraulics lab to support the Mississippi River Commission and control the flooding in the Mississippi Valley.

Since then we've grown in both size and sophistication to where now we are a world-class sophisticated laboratory in many areas. We are a complete organization in that we have everything that we need to support ourselves. We are a self-sustaining, complete post, with everything from a PX to fine research facilities. We have technical staffs that support each of the five laboratories, but the administrative and advisory staff is shared among them. We do research in hydraulics, geotechnical, structures, environmental, and coastal engineering.

We do not receive any money directly from Congress as a line item in the budget. All of our work is on a reimbursable basis or direct-funded out of the Office, Chief of Engineers (OCE), in both military and civil works. Most people think that all of our work is done for OCE, but some of it is also done for the Air Force. Our program this year will be about $113 million. We actually have about $160 million of work to accomplish. We accomplished around $110 to $113 million this year. It's about 50-50 military/civil. Our current staff at WES, which consists of about 1,800 people, comes from diverse regions of the United States, ranging from North Carolina to the deserts of Arizona and New Mexico. We have 105 Ph. D.'s on our staff. We have a technical support staff of about 700 and an administrative and advisory staff of about 173.

Besides the commander and the deputy we have 18 to 20 military personnel who work either in pure research or as coordinators--an interface between the researcher and the customer who is frequently the Army, Navy, or Air Force.

We have a 685-acre establishment here. The lake on the grounds was built back in 1932 to supply water for the models. It's now used for things such as mobility, egress, and access to the riverbanks.

In the Hydraulics Laboratory is a model of Kings Bay, which is the new home of the Trident submarine, where we're working both on sedimentation and currents that might affect nuclear subs. We're also doing work to improve the water quality in lakes and streams resulting from destratification of water during the warm months.

The Coastal Engineering Research Center (CERC) is not the biggest lab, but today it's the most important lab in the group. Of course, CERC works in the area where the ocean meets the land, and in structures, wave dynamics, and sedimentation utilizing physical and numerical models. We have a super research facility at Duck, North Carolina, where we can study the effects of the waves as they approach the beach. We have a 1,840-ft pier and special equipment, such as the Coastal Research Amphibious Buggy (CRAB), which is a coastal engineering research vehicle powered by a little Volkswagen engine. In some of our physical models sedimentation studies are being done, and the goal is to build functional, economical, and environmentally sound structures along our coast. We also use mathematical models for looking at storm surges in the northeastern part of the United States.

The Geotechnical Laboratory works in soil and rock mechanics, engineering, geology, pavements (one area that's probably not well known to this group), and vehicle mobility. We're the center of mobility for the Department of Defense. If you're going to move a spacecraft on land, or if you're going to build a new M-1 tank, the mobility studies are done here at Vicksburg, Mississippi, while the inexpedient construction work is done for overseas. The Geotechnical Laboratory is very well equipped. One of the things we're working on now is finding cavities underneath civil works structures. This also has a military application. The same techniques can be used to find tunnels in the military environment where somebody is trying to tunnel underneath you.

One of the things we developed--this is a military item, but it has some application to coastal engineering as well--is a sand grid. It's a plastic system we developed. You spread it out in the sand, fill it with sand, and then run vehicles over it. We had two super tests last year and the year before at Fort Story when we passed about 2,000 container loads from ships in the sea over this sand grid plastic road successfully to the shore. They would not have been able to do this without the sand grid road.

The Structures Laboratory is the Corps' center of expertise on concrete technology. They do some exciting things in explosion effects, geomechanics, protective structures, and structural mechanics. One of the things we're doing now, which generally is classified, is constructing and testing model silos. We build them with great precision for the Air Force, and we statically test them in the laboratories. Of course, they end up with concrete around them before they're done, and then we have great fun blowing them up and figuring out how to make them better.

We also have a division of explosive antitank obstacles. We developed a pipe system, which is really a nice tank trap, in which plastic pipe is placed in the ground, filled with a blasting agent, and then detonated. There's a 500-m one at Fort Polk, Louisiana, and it stops the finest tanks in the world. There's a new XM-1 in there and a German Leopard II, and they can't get out. We have also the mission of explosively clearing mine fields employing techniques we've used similar to those with the plastic pipe and the blasting agent. We do testing on protective structures. We do work for the Federal Emergency Management Agency (FEMA), the Federal Republic of Germany, and the Department of Defense with small yield nuclear simulation.

The Environmental Laboratory has a two-fold mission: determining the effects of civil works projects on the environment and looking at the interface between military operations and the environment. The Environmental Laboratory also studies disposal of dredged materials and ways to make these materials productive. Most of our new weapon systems rely on optical or electrical sighting systems. If you create dust with tanks, munitions, nuclear weapons, or whatever, we need to know the effects on these sophisticated systems. We're doing research in that area also. That's environmental engineering military application.

We're proud here at the Waterways Experiment Station, and I'm a transient; therefore, I can say that they really do a good job. We're proud of our contributions to the Nation and to the Department of Defense and we will continue in that direction.

One of the important things for any research organization is to get the word out to the people who may use it. We run numerous classes, seminars, and workshops. We have several going on right now out at WES where we try to transfer the results of our research or that of anybody else. We are pretty good with not having a problem with "invented here." Our job frequently is to find out what is done elsewhere and to transfer it to the Army and to the Department of Defense so we can use it. Our scientists and technicians are ready to solve those problems that need to be solved within our mission and scope.

I thank you for giving me this opportunity to speak with you. And again, welcome to WES and to Vicksburg, Mississippi.

REVIEW OF COASTAL ENGINEERING RESEARCH BO.RD BUSINESS

COL Robert C. Lee, Executive Secretary
Coastal Engineering Research Board
Commander and Director, US Army Engineer
Waterways Experiment Station

It was recommended at our December meeting in Chicago that the Board be given an orientation on the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Program. Mr. William F. McCleese, REMR Program Manager, will make this presentation immediately following my remarks.

In regard to other requested briefing items, I have asked Dr. William L. Wood and his staff to provide an update on the Crescent City Dolos Project during this afternoon's session. Tomorrow afternoon, Dr. Wood and Mr. J. Michael Hemsley will brief the Board on Coastal Field Data Collection (CFDC) and Monitoring Completed Coastal Projects (MCCP). Dr. Houston will brief the Board on the planned research program for our directional spectral wave generator.

In response to Professor Wiegel's inquiry about the Chicago Park District's use of the wave tanks under Soldier Field for design of their projects, General Hilmes and his North Central Division (NCD) staff obtained the information cited below.

LOYOLA BEACH

Until 1950, Loyola Beach was a narrow gravel beach not more than 50 to 100 ft wide. This beach was tested in the Soldier Field wave tank in 1950, and in 1951 wood groins were extended into the lake. In 1961 these wood groins were sheathed in steel sheetpiling and capped with concrete. Since 1951 the gravel beach has built out another 150 ft due to accretion from the north.

LINCOLN PARK PERCHED BEACH

The design of the perched beach was tested in the Soldier Field wave tank in 1936. There was some semblance of a beach before this time due to wood groins built about 1920. In 1936 the perched beach was built using the existing wood groins and a perimeter of submerged steel sheetpiling (-4.0) to contain the sand (pumped in on a slope of 1:25). In 1961 the wood groins were sheathed with steel sheetpiling and capped with concrete. Riprap was placed on the landward side of the submerged bulkhead, and sand was trucked in and pushed into the water to be dispersed by wave action. They lost some sand from the system, but to date no emergency measures have been required.

OTHER WAVE TANK TESTS

Wave tank tests for the following locations have been performed since 1935 and all have proven reasonably satisfactory.

(1) Navy Pier
(2) Diversity Harbor Entrance
(3) Belmont Harbor-Courtesy Boat Dock
(4) Calumet Park Perched Beach
(5) 12th Street Perched Beach
(6) Columbia Street End Beach Groin
(7) Foster Avenue Beach
(8) Ardmore Beach
(9) Montrose Beach Hooked Pier

All of the above projects were designed by Chicago Park District engineers, and all shore protection improvements since 1935 were tested in their wave tank under Soldier Field. Time has proven that these rather "crude" qualitative tests were very reliable.

CALUMET CONFINED DISPOSAL FACILITY

Relative to Mr. Bascom's question about the membrane installed at the Calumet Confined Disposal Facility (CDF), General Hilmes reports that this was not a highly successful application of an impermeable membrane. The engineers had to weight the interior face of the membrane with stone to prevent hydrostatic uplift, and this ballasting caused tearing of the membrane. They solved the leakage problem by excavating silty sand from the interior lake bed and banking it against the inside face of the dike. They do not recommend impermeable membranes for this type of structure.

REMOTE SENSING

As we promised in the December meeting, I have prepared a few remarks regarding remote sensing in our Research and Development (R&D) program. The Coastal Ocean and Dynamics Applications Radar (CODAR), the shore-based, high-frequency coastal radar recently acquired by the Coastal Engineering Research Center (CERC), underwent its initial field demonstration during October and November 1984. The experiment, a joint effort with the National Oceanic and Atmospheric Administration (NOAA), was conducted on lower Delaware Bay. Its purpose was to demonstrate CODAR's unique ability to measure surface currents over a large areal extent. Two radar sites, 27 km apart, were established and maintained for approximately 5 weeks. Figure 1 shows the antenna deployment at the base site. Each site provided a two-dimensional map of radial surface currents which, when combined, produced a map (Figure 2) of the total surface current velocities. In addition to measuring surface currents, CODAR was used also to track active transponder/drifters (Figure 3). Information gathered from these drifters, shown here as a plot of drifter trajectory (Figure 4), provides a check on CODAR current measurements and offers further insight into circulation patterns. More detailed information on CODAR and the Delaware Bay experiment can be found in Appendix A.

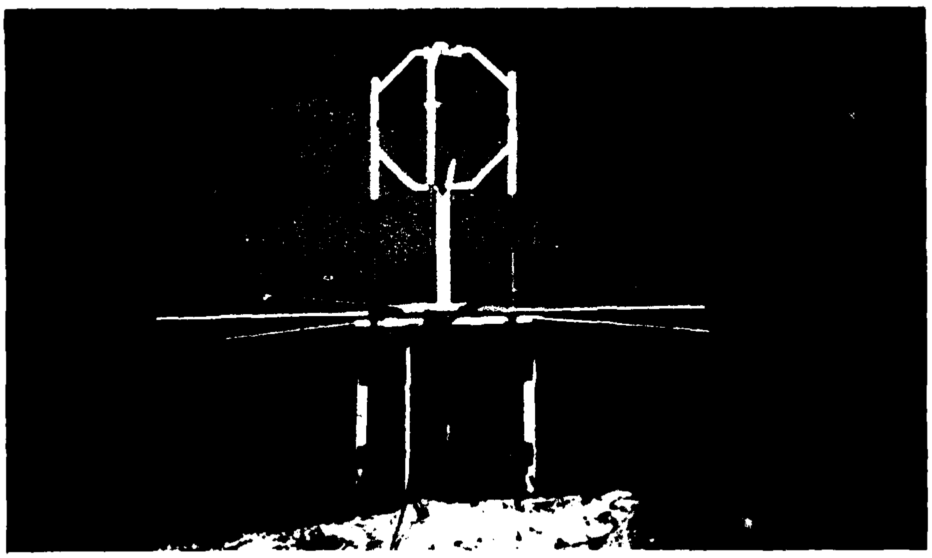

FIGURE 1. DEPLOYMENT OF ANTENNA AT BASE SITE

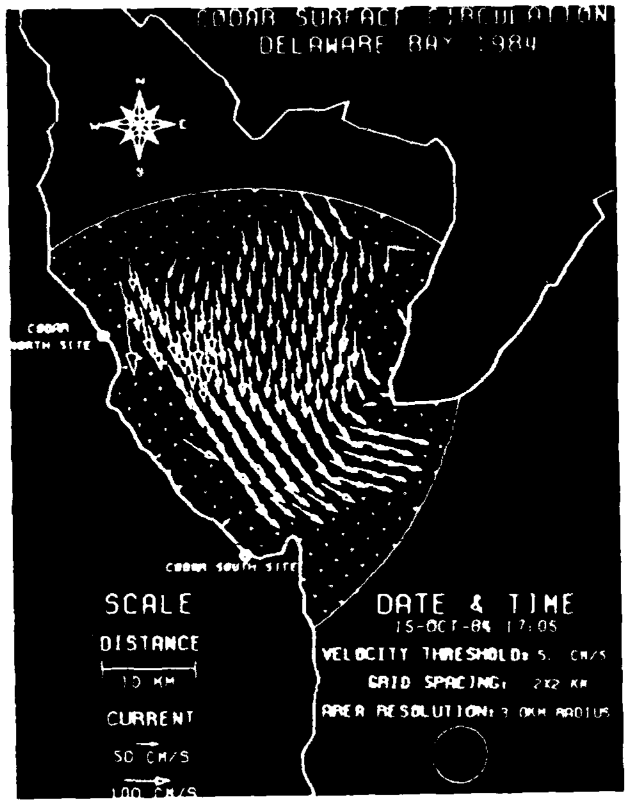

FIGURE 2. MAP OF TOTAL SURFACE
CURRENT VELOCITIES

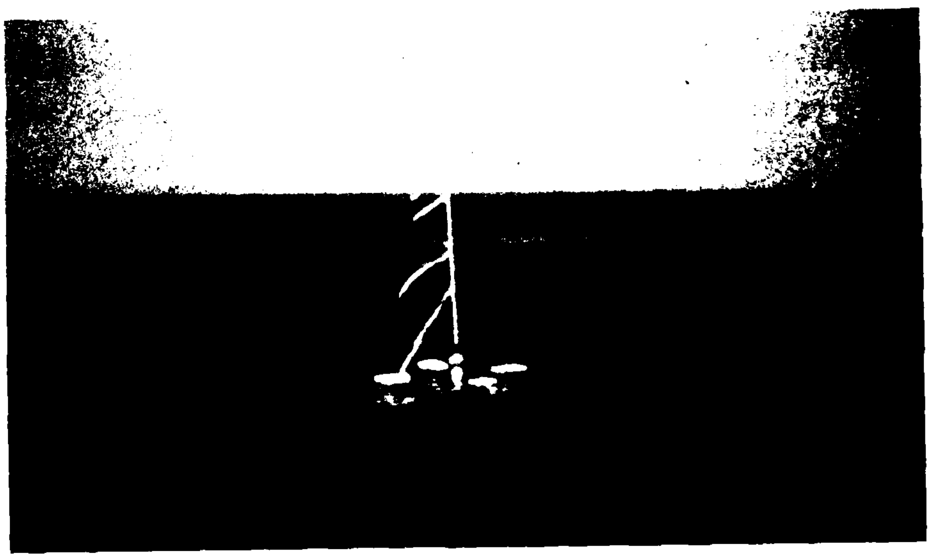

FIGURE 3. TRANSPONDER/DRIFTER

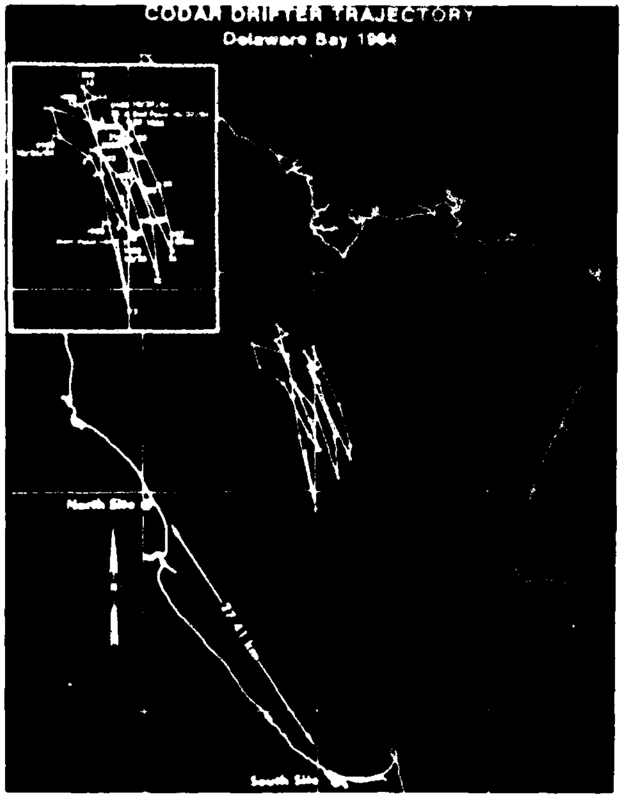

FIGURE 4. CODAR DRIFTER TRAJECTORY

EFFECTIVENESS OF EXPEDIENT LEVEE RAISING STRUCTURES

Another R&D item mentioned at past CERB meetings is the effectiveness of expedient levee raising structures. Our current study is being conducted at prototype scale to determine the static differential head and wave action load limits beyond which selected existing Corps of Engineers (Corps) designs of expedient levee raising structures will fail. In addition to existing designs, new concepts and improvement on existing designs were tested as time and funding allowed. Testing of 2- and 4-ft-high structures has been completed, and the last 6-ft-high structure presently is being tested. A comprehensive report on this test series will be completed this fiscal year. Figure 5 shows wave action on plywood flashboard with tamped earth fill (landside view); Figure 6 shows wave action on planking mud boxes with earth fill (landside view); Figure 7 shows wave action on sand-filled plastic grid (riverside view); and Figure 8 shows a 3.0-ft static differential head on sandbags (woven and spun woven polypropolene and burlap sacks).

FIGURE 5. WAVE ACTION ON PLYWOOD FLASHBOARD WITH TAMPED EARTH BACKING (landside view)

FIGURE 6. WAVE ACTION ON PLANKING MUD BOX WITH EARTH FILL (landside view)

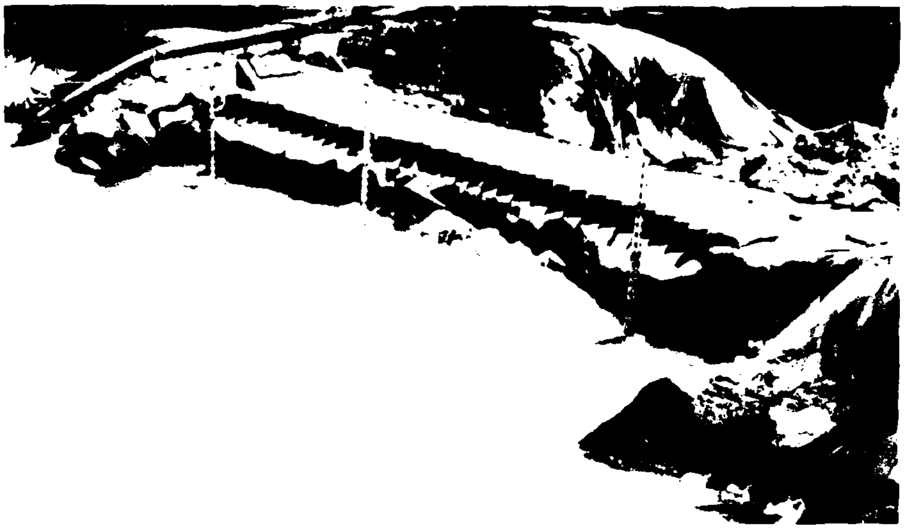

FIGURE 7. WAVE ACTION ON SAND-FILLED PLASTIC GRID (riverside view)

FIGURE 8. STATIC DIFFERENTIAL HEAD ON SANDBAGS (landside view)

CONCLUSION

As you know, General Edgar has instituted a policy of inviting one or two Corps Divisions, other than the host Division, to present their research needs at each CERB meeting. This makes these meetings less regional and more national in scope. Consequently, for the 43rd Meeting we invited the Lower Mississippi Valley Division (LMVD) and the Southwestern Division (SWD). We will be hearing from LMVD on Friday.

CERB Proceedings

THE REPAIR, EVALUATION, MAINTENANCE, AND REHABILITATION (REMR) RESEARCH PROGRAM

COL Robert C. Lee
Commander and Director
US Army Engineer Waterways Experiment Station

Mr. William F. McCleese
Program Manager
REMR Research Program
US Army Engineer Waterways Experiment Station

CPT Wylie K. Bearup
Deputy Program Manager
REMR Research Program
US Army Engineer Waterways Experiment Station

ABSTRACT

Our nation's infrastructure has decayed to the point that vast sums of money are now required to keep its many elements in operating condition. Corps of Engineers (Corps) projects, which represent a very significant portion of the infrastructure, have experienced this same decay. In response to the need to prolong the life of existing structures, the Corps initiated the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program. The overall objective of the REMR Research Program is to identify and develop effective and affordable technology for maintaining and, where possible, extending the service life of civil works projects.

INTRODUCTION

The media have devoted much attention to the condition of America's infrastructure--the network of public facilities that provides for our Nation's mobility, shelter, services, and utilities. To keep the various elements of the infrastructure in operating condition, vast amounts of money are now required. Early estimates were a bit excessive, but it is now generally accepted that about $1 trillion will be required this decade to keep our public facilities in serviceable condition.

Reasons for the present condition of our public facilities are many, but the most significant has to be reduced spending. From 1965 to 1981 the Nation's gross national product increased by 62 percent, but expenditures for public facilities decreased by 19 percent.

Corps of Engineers (Corps) civil works projects represent a very significant portion of the infrastructure and have experienced this same decay, largely due to their increased age and greater than projected use. Corps projects provide for transportation on inland waterways, generation of hydropower, development of water supplies, flood control, and coastal protection.

Until the past decade, when a Corps project reached the point that major repairs or rehabilitation were required, it was generally time to replace it with a larger, and often multipurpose, project. However, because of the frequently discussed strain on the Federal budget, it was necessary to reduce the construction rate of new civil works projects. Since it is generally more economical to rehabilitate an existing project than to build a new one, vast savings could be realized by keeping projects in service longer. In some cases it has been necessary to keep Corps projects in operation long past their original design service life (Figure 1).

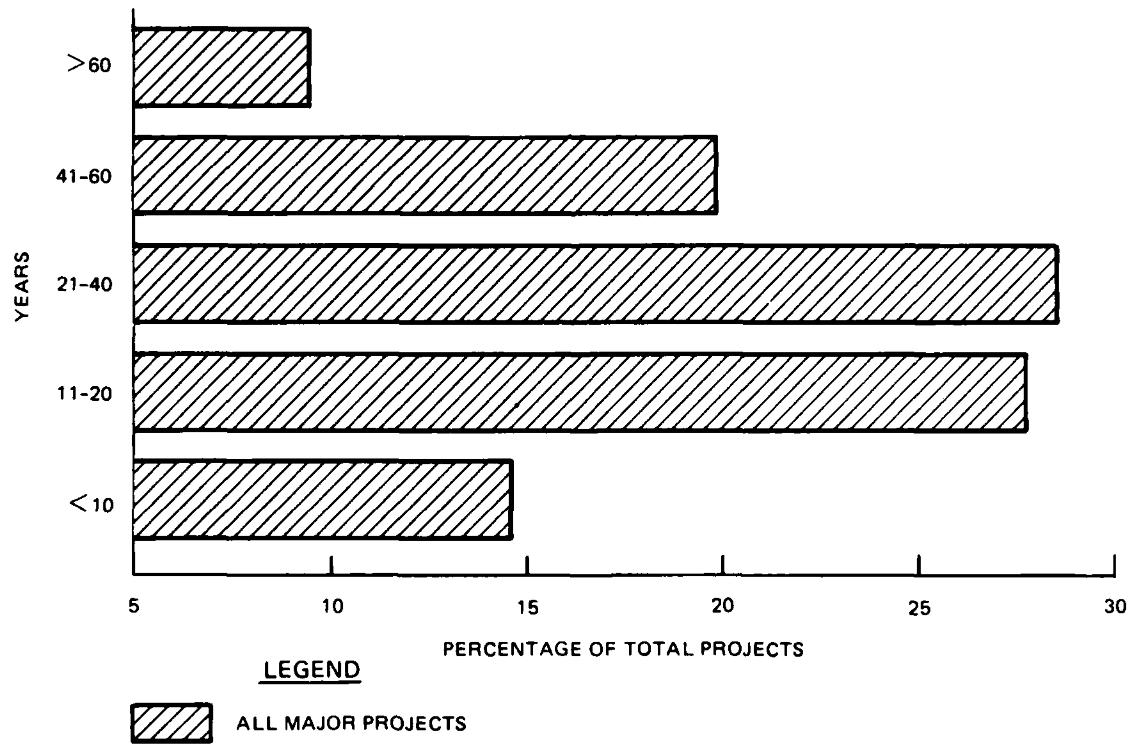

FIGURE 1. AGE OF CIVIL WORKS PROJECTS (Total of 596 major Corps projects)

As new construction starts have decreased, the Operations and Maintenance (O&M) requirements of the Corps' civil works budget have been steadily increasing, beginning in the late 1960's. In 1984 the O&M budget exceeded the construction budget for the first time in recent history, and this trend is expected to continue (Figure 2).

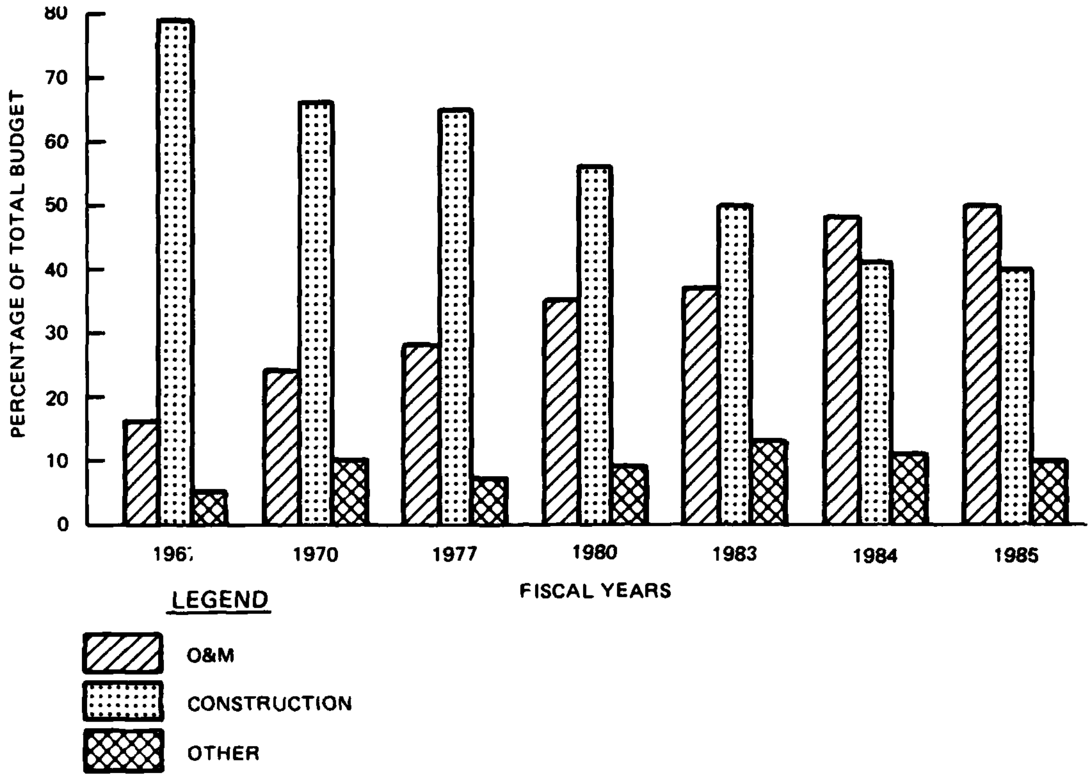

FIGURE 2. CIVIL WORKS APPROPRIATIONS, 1967-1985

At present, technology for prolonging the life of existing structures is not as advanced as the technology for building new structures. The Corps has developed considerable expertise in planning, designing, and constructing new hydraulic structures, and in the past that was the area with budgetary priority. However, uniform guidance must now be developed for repair and maintenance techniques to keep these aging civil works projects in service.

It was in response to this need for new technology that the REMR Research Program was initiated by the Corps in 1983. The overall objective of the REMR Research Program is to identify and develop effective and affordable technology for maintaining and, where possible, extending the service life of civil works projects. It is incumbent upon the Corps to get the maximum return for the money spent on maintaining, repairing, and rehabilitating its projects.

The REMR Research Program is designed to extend over a 6-year period with a total budget of $35 million and will involve all of the Corps' research and development (R&D) laboratories, which include all five laboratories at the Waterways Experiment Station (WES) (Structures, Geotechnical, Hydraulics, and Environmental Laboratories and the Coastal Engineering Research Center), the Construction Engineering Research Laboratory, the Cold Regions Research and Engineering Laboratory, and the Engineer Topographic Laboratories.

The Corps operates and maintains approximately 600 major civil works projects which are constructed of various materials and are subjected to a wide range of climatic and environmental conditions. By necessity, the REMR Research Program is very broad in scope, but it will also address specific problems encountered by field personnel during daily, routine operations. The first step in developing the program was to identify the deficiencies and needs that exist in the field. This was completed in 1983 and resulted in publication of a development report which established the broad framework for the program.

PROBLEM AREAS

For management purposes, research requirements were organized into seven problem areas: Concrete and Steel Structures, Geotechnical, Hydraulic, Coastal, Electrical and Mechanical, Environmental Impacts, and Operations Management.

There are three basic objectives of the Concrete and Steel Structures Problem Area. The first objective is to evaluate the ability of concrete and steel structures to perform their intended functions in a given environment. Examples of the types of structures to be evaluated are locks and dams, outlet works, retaining walls, sluice gates, piles, bulkheads, bridges, tunnels, and stilling basins. The second objective is to identify material as well as structural and functional problems affecting concrete, steel, and associated construction materials. Identifying methods to alleviate O&M problems relating to concrete and steel structures is the third objective. Over half of the Corps' navigation locks are over 40 years old. These older structures were built prior to the advent of air-entrained concrete, and many exhibit severe freeze-thaw deterioration requiring extensive renovation, as shown in Figure 3. Total rehabilitation usually costs one-tenth to one-fourth as much as replacement with a new structure.

FIGURE 3. EXAMPLE OF NAVIGATION LOCK EXHIBITING FREEZE-THAW DETERIORATION

The primary concerns in the Geotechnical Problem Area involve remedial measures for seepage problems, liquefaction susceptible foundations, slope protection, and improved repair and rehabilitation procedures for rock foundations. Procedures will be developed to assess structural foundations, evaluate remedial seepage control measures, predict erosion rates and extent of erosion for rock spillway channels, and identify preventive measures. Many Corps structures are located on liquefiable foundations which can result in catastrophic failures under certain conditions, as shown in Figure 4. Under the REMR Research Program techniques will be developed to economically and effectively improve the structural integrity of these foundations and reduce the risk of failure from seismic activity.

The Hydraulics Problem Area, which is divided into the subareas of Flood Control and Navigation, will consider the hydraulic performance of inland and estuarine channels and structures. Research will develop technology to extend the service life of hydraulic structures by improving methods for scour protection and control of floating debris. Rehabilitation and maintenance operations which will result in improved and safer navigation conditions will also be developed.

Coastal structures, harbor entrances, coastal channels, shore

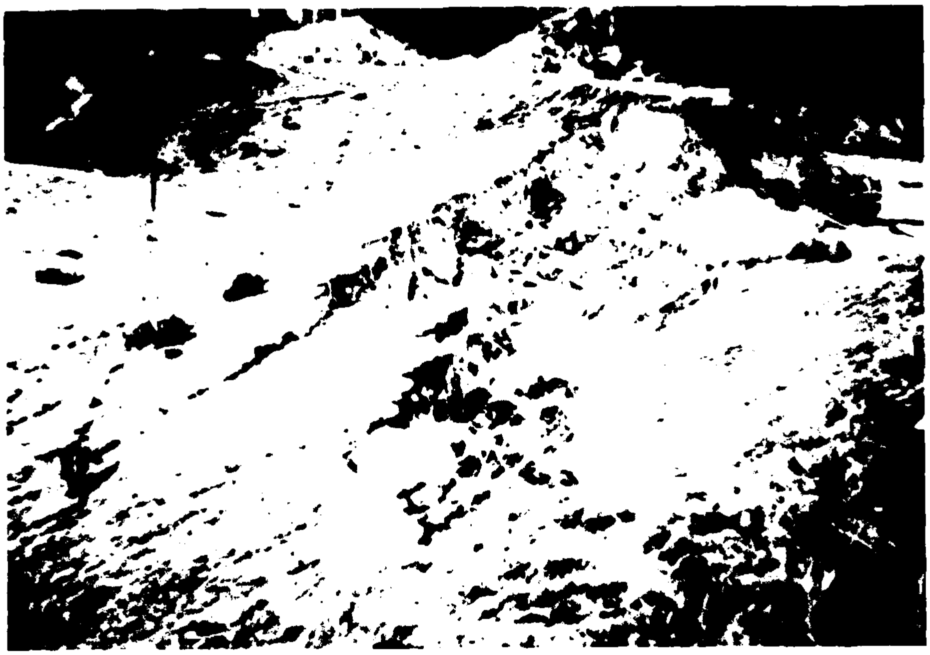

FIGURE 4. EXAMPLE OF LIQUEFIABLE FOUNDATION FAILURE

protection, and shore restoration will be considered in the Coastal Problem Area. Research will address the rehabilitation and repair of coastal structures which protect beaches and harbors. Methods and techniques will be developed for minimizing maintenance requirements of navigation channels and beaches.

The Electrical and Mechanical Problem Area will develop maintenance techniques for pumps, generators, valves, coils, and other metallic elements and, in general, all electrical systems. Improved nondestructive testing techniques are being developed for evaluating the condition of deteriorated metal surfaces and for predicting remaining life for reliable service (Figure 5). The primary research thrust will be to develop maintenance techniques, establish criteria for the feasiblity of repair, and then recommend replacement materials and procedures.

The Environmental Impact Problem Area will be primarily concerned with determining the impact on the environment of recommended REMR techniques and materials suggested by the other problem areas. The techniques and materials will be evaluated to identify impacts, quantify magnitudes, and recommend remedial alternatives when necessary.

The Operations Management Problem Area will develop a management system that will draw on the technology generated by the other problem areas and

FIGURE 5. NONDESTRUCTIVE TESTING TECHNIQUE

provide management with a tool to better manage its vast REMR activities in the future.

MANAGEMENT

To accomplish the required research activities, work units have been established to address specific deficiencies and needs identified in the formulation stages of the program. A principal investigator has been assigned to each work unit to manage the research effort. The actual research work is being done in a variety of ways. It may be accomplished by in-house laboratory personnel, by support from other Corps offices and other government agencies, or by contract agreements with universities and private firms.

Overall management of the REMR Research Program is by the Directorate of Research and Development at Headquarters, US Army Corps of Engineers (HQUSACE). An Overview Committee has been established at HQUSACE to scope and direct the program and to establish research funding levels. To manage the day-to-day activities of the program, a Program Manager was appointed in the Structures Laboratory at WES. The program Manager, Mr. William F. McCleese, also directs technology transfer efforts.

Most of the research work within a given Problem Area will be done within a single R&D laboratory, and a senior engineer in that lab has been assigned as the Problem Area Leader. Problem Area Leaders manage and coordinate the research efforts in their areas, ensuring that the research is being conducted on schedule and within funding limits.

To provide field input to the program, a 12-member Field Review Group has been formed representing each Corps Division having civil works responsibilities. The Field Review Group performs broad technical review of REMR problems, provides continuous field input, recommends research priorities, and assists in technology transfer.

TECHNOLOGY TRANSFER

A technology transfer plan has been developed and adopted to ensure that information and research results get to the field as rapidly as possible. A variety of media will be used for technology transfer so that the targeted individuals and organizations can receive the information they need.

The REMR Bulletin is a short information exchange newsletter with information about ongoing REMR-related activities and upcoming events. It contains articles written by field personnel about their experiences in solving maintenance and repair problems that may be of assistance to others confronted with similar problems. To date, five issues have been published and distributed to over 2,000 personnel throughout the Corps, other government agencies, universities, and private industries.

The REMR Notebook, containing fact sheets summarizing methods and materials for use in REMR activities, will be a major technology medium. Looseleaf format will be used to allow easy update and revision.

Five REMR workshops and seminars have been conducted during the past year, and more are planned. The workshop titled "Underwater Inspection and Repair of Hydraulic Structures" was videotaped, and copies are available to personnel who were not able to attend.

Briefings and presentations on research results and progress will be given as appropriate at conferences both within and outside the Corps. Research results will also be published in engineer manuals, circulars, technical letters, pamphlets, and guide specifications as deemed necessary by HQUSACE.

A phone-in system called the REMR Hotline has been organized to allow field personnel with special problems to make direct contact with research personnel who are working in that Problem Area. Table 1 lists contact and phone numbers for each Problem Area in the program.

TABLE 1

REMR HOTLINE

Contact	Problem Area	Phone Number
Jim McDonald FTS 542-3230	Concrete & Steel	601-634-3230
Britt Mitchell FTS 542-2640	Geotechnical (Soils)	601-634-2640
Jerry Huie FTS 542-2613	Geotechnical (Rock)	601-634-2613
Glenn Pickering FTS 542-3344	Hydraulics	601-634-3344
D. D. Davidson FTS 542-2722	Coastal	601-634-2722
Jerry Mahloch FTS 542-3635	Environmental Impacts	601-634-3635
Paul Howdyshell	Electrical & Mechanical Operations Management	217-373-7244 FTS 958-7244

CONCLUSION

The REMR Research Program is now in its second year. In 1984 the primary thrust was to determine the state of the art in various REMR areas and to gear up for a large research effort this year. In 1985 the program has reached full stride, with research under way in 52 different work units. One principle of the REMR Program is to make maximum use of existing technology and field experience, and a great deal of effort is being directed toward collecting, documenting, and reporting experiences.

The REMR Research Program is currently the largest single research program in the Corps. Research results obtained during the program will be shared with other government agencies and the private sector. Much of the technology will be transferable to other than Corps projects and as such will provide substantial benefits to the nation in meeting its total infrastructure needs.

DISCUSSION

PROF. WIEGEL: *First, I want to thank you very much because there is just no question about it that one of our main problems in the United States and many other countries is that so many of our structures are wearing out. It's a real tough problem. Since a lot of these structures were built — say a bridge or a dam built 40 or 50 years ago — our ideas on earthquake resistance design have changed. There is also the possibility of liquefaction of a foundation, and this exists in several Naval facilities that were built during World War II. Are up-to-date analysis techniques to study the problems of earthquake resistance design a part of the REMR program?*

MR. McCLEESE: No sir. Under the REMR program we're looking at techniques to prevent liquefaction failure once we know it is located on a foundation which is potentially liquefiable. We are just looking at the techniques to correct or strengthen that foundation so that we minimize the possibility of liquefaction.

BG EDGAR: I wish to interject a thought here and ask Mr. Lloyd Duscha, Deputy Director of Engineering and Construction and very much involved in dam safety, to respond to that, Bob.

MR. DUSCHA: Yes, Professor Wiegel, we are looking at each one of our dams under a different program. Our earthquake problem areas are being analyzed for both liquefaction and the other types of problems. We have gone through a great number of dams already, and we have to do some corrections on them.

BG PALLADINO: *First, I enjoyed the presentation. I noted at the beginning that you mentioned information about the REMR program and a publication such as Military Engineer. I suspect you may be doing it, but there may be value in broadening the scope of information about the program to agencies and publications outside the Corps and Army family into the professional societies and local communities and others which would have an interest. Is there any activity on that line?*

MR. McCLEESE: I have talked to the assistant editor of Civil Engineering, a magazine which gets very broad coverage. We have talked about the possibility of getting an article in that particular magazine, and he's very receptive to it. I think fairly soon we will get something in it.

BG PALLADINO: Even beyond the engineering community I think there is great value in this program, and it deserves some public recognition in terms of the efforts on behalf of the Army and the Corps.

BG EDGAR: I think that's very true, Don; and for Bill's information and for members of the Board, last fall the Chief met with the president of The American Society of Civil Engineers (ASCE) and the executive group in the headquarters. The principal members of the staff were there also, and we discussed a number of things with them, one of which was REMR. I think that Don's point is well made.

We mentioned what we were doing in REMR, not in as complete detail as you did because we didn't have a slide presentation; it was more discussion, but they expressed great interest. So armed with that and your discussions with the editorial folks, I think the time is certainly right to do something in the ASCE magazine, particularly since we now have PL98-501 which is the infrastructure repair. The President has already begun to announce his appointees to the Council for which the law provided. Things are beginning to move now with reference to that activity, and I think information in the ASCE magazine, for example, would be very timely. I believe the technological transfer aspects are many, and the Corps needs to get the recognition that it deserves because I'm not aware of anybody else in the country who is doing anything such as this. There may very well be but it is not readily apparent. And I think that if we publish this article, given the Corps' responsibilities under PL98-501, it just adds more to the credibility of why we're there and what we can do in seeing that something is done about improving the infrastructure of our country.

MR. McCLEESE: There are a couple of instances in which we have reached outside of the Corps. I gave a briefing to the American Waterways Operators of the Southern Region in Greenville a couple of weeks ago. Also, I briefed the American Public Works Association a couple of times and had good contact with the president of that organization, Mr. Sullivan, who was at our Portland meeting. They are also having a Mississippi section of the American Public Works Association meeting this week; and Captain Wylie Bearup, who works with me, will be attending that meeting down on the Gulf Coast. We can do more though, and we will look into that.

BG PALLADINO: I have a second comment, Ernie, along the same lines. You touched upon the infrastructure, and perhaps this is under way; but there would seem to be some value in pulling together the team and preparing for the annual reports to Congress which start in about a year. It may be of great value to have a Corps strategy to ensure that we properly integrate the requirements of REMR into that activity to include the recognition of research and development (R&D) needs associated with that program.

BG EDGAR: You must have read my note, Don. Dr. Choromokos, under the remaining items portion of Civil Works testimony to Congress, reports on R&D needs. To Jess Pfeiffer and Bill Roper, let's make sure that REMR is very much a part of Dr. Choromokos' presentation, particularly as it focuses on PL98-501. You know, we can talk about what we've done at Brandon Roads and some of these other activities, but I have not been very successful in getting members of our committee down to Brandon Roads and some of the work that we've done in North Central Division (NCD). We tried unsuccessfully last year to do that. I think it's very important they understand where we're coming from, what we have done, and what we could do with appropriate funding levels. So I think you've got a great opportunity.

MR. PFEIFFER: It would probably be well, too, sir, if you could get from the Office of Management and Budget (OMB) some of our examiners to go along with that group.

BG EDGAR: I have no problem with that, most certainly. I would think that Don Cluff would be very amenable to such a thing, and I don't want to take up any more time of our group here, but we need to talk about that a little bit more.

PROF. WIEGEL: *Because you are kind of pushing ahead on this, as many other people in this country should be, could you prepare something that we in universities could take a look at to see how we might modify existing courses or what sort of new courses we can devise based upon your experience on this REMR thing? In other words, how can we look at things differently from how we're looking at them now? Or perhaps we can't. I don't know, but I think that anything you can give us would be quite beneficial.*

MR. McCLEESE: I would certainly be happy to put you on the distribution list for a REMR Bulletin and the other information we're putting out in the program. The program is very broad right now, and we're just getting started on it. We're assessing existing technologies and trying to spread the word on those. But I really don't have any suggestions at this time on how you could modify a course. I was at a workshop at MIT a couple of weeks ago where they were discussing this very thing concerning the need to have a curriculum to address this type of technology as opposed to the traditional curriculum for engineers. Perhaps they've got something in writing, but I haven't received the results of that workshop yet. They're supposed to send me something, and perhaps they'll have some valuable information on that particular item in the literature which I'll be glad to send to you.

PROF. WIEGEL: I'd appreciate it.

BG EDGAR: Bill, thanks very much for a very fine presentation.

MR. McCLEESE: Thank you.

BG EDGAR: I want to take a few moments to put into focus or sharpen the focus, if you will, on most of the rest of the day's presentations, at least through 1600 this afternoon.

Most of our discussion today will focus on concerns about better understanding the coastal engineering responsibilities of the Corps. The Board indicated a consensus that they felt a need to get more involved in their advisory capacity to the Chief of Engineers than we have necessarily in the past. Since such involvement includes budgeting, planning, engineering, and operations, these topics serve as the basis of our discussion this morning and a part of the afternoon.

To help the civilian members of the Board to better understand where the Corps is coming from in the coastal engineering arena, I asked that the senior members--executive members of the Corps staff--come and make presentations in their various areas of responsibilities. And they are here, almost without exception. In those cases where that individual was not available to come, he has a very able representative.

OCE and our Field Operating Activities (FOA's) are organized by function --as those of us within the Corps family know--i.e., planning, engineering, and construction, readiness, policy, and so forth. This may appear confusing to our civilian members who perhaps might not quite understand our organization; and hopefully, by the presentations that our senior executive members give here this morning, you will better see how all of these fit into our various mission responsibilities.

Insofar as the Board's present responsibilities are concerned, I'll read not only our charter but also give you an overview of the public law which established us as we now exist. And that is Public Law 88172 which was enacted back in 1963. Essentially what that act did was to abolish the Beach Erosion Board, which was our predecessor, and establish our organization and the Coastal Engineering Research Center. The CERB assumed the functions of the Beach Erosion Board. A portion of that law reads:

> The functions of the Coastal Engineering Research Center shall be conducted with the guidance and advice of a board of coastal engineering research, constituted by the Chief of Engineers in the same manner as the old Beach Erosion Board. All functions of the Beach Erosion Board pertaining to review of reports and investigations made

> concerning erosion of the shores of coastal and lake waters and the protection of such shores are hereby transferred to the Board.

From that we have our charter, which essentially says we meet semiannually at the call of the president. We provide board policy guidance and review of plans and funding requirements for the conduct of research and development in the field of coastal engineering. We recommend priorities for accomplishment of research projects and, consistent with the needs of the coastal engineering field and the objectives of the Chief, we perform additional functions as assigned by the Chief of Engineers. And the latter one probably addresses what we're talking about in our session this time, that is, what we might recommend to the Chief to see whether or not there are some other things that we may wish to get into.

Now , I think we should also bear in mind when that transfer went from the old Beach Erosion Board to our present organization under law, the GI portion, that is the review of the feasibility reports, was no longer vested with us but went to the Board of Engineers of Rivers and Harbors, of which Colonel John Devens is the resident member and John McCann is the Technical Director. So, that is a slight difference from what it used to be many many years ago; nonetheless we have an opportunity, I think, to reexamine with this session where are we now and where we may decide we would like to go and make those thoughts known to the Chief.

Just as an overview thought, and for the edification of our civilian Board members, the District role in the Corps is that of project planning, design, and operation. They are the executors. They are the ones right there on the ground. The Division office, to which they report, provides review responsibility and a capability. The OCE role is one of approval of policy and a certain level of review. The R&D role, as Bob Lee has pointed out in his overview, is mission-related R&D and mission support to the FOA's on a reimbursable basis.

One of the things that has come up in our discussions, both in Chicago and earlier, is the role of basic research and applied research in coastal engineering. I think Robert Whalin will perhaps talk about this a little bit.

Certainly we're concerned about coastal field data collection and the funding level for wave gaging. I think Robert will also talk about that, and I would certainly hope that Dr. Bory Steinberg will do the same. We will then, of course, have the opportunity to view the CERC facilities, on site, at WES before our meeting adjourns.

I'd like to just add a couple of thoughts from what I had said earlier before the break. One is a very personal one, which I meant to say at the very beginning. Many of you know Gene Chatham, and I regretfully say his father passed away; therefore, he will not be with us. We have a card which the members of the Board will be signing. All those present who wish to add their names to that card, please feel free to do so. Robert Whalin has it, and you can do so during the course of the day.

During the break, Bill Roper and Jess Pfeiffer were talking to General Palladino who pointed out that the Chief is going to be out on the West Coast in September for a major presentation to APWA. It would seem to me that the key point in that presentation would be an expansion of what Bill just gave us on REMR, certainly as part of it. I commend that to you so you can get together with Bill and see what you can do to influence that action, and I'm going to send a note to the Chief in order that he can consider it as well.

We talked about next year's budget presentation to Congress. I've had even a better idea to add to that. I think we ought to try to set something up with the committees between now and then to either give to the staff--or to certain members who would like to hear it--something on REMR so that they will be sensitive to what we have done between now and the time for next budget testimony.

CERB
Proceedings

COASTAL ENGINEERING RESPONSIBILITIES OF THE PROGRAMS DIVISION

Dr. Bory Steinberg, Chief
Programs Division
Directorate of Civil Works
Office, Chief of Engineers

ABSTRACT

The function of the Programs Division with regard to coastal engineering activities is outlined in relation to the total Corps of Engineers program and the outlook for future coastal projects.

INTRODUCTION

General Edgar, members of the Coastal Engineering Research Board, ladies and gentlemen, I welcome the opportunity to describe our responsibilities in relation to coastal engineering activities.

FUNCTIONS OF PROGRAMS

The Programs Division in the Directorate of Civil Works is responsible for the development, defense, and execution of the annual and multiyear Civil Works programs, including those parts of the program that are of interest to the coastal engineering community. These programs provide the basis for the annual, supplemental, and other appropriation requests for all Civil Works activities.

In the Programs Division we issue guidance to the Field Operating Activities (FOA's) for the development of their programs based upon the policies established by Congress, the President, and the Secretary of the Army. We review, adjust, and integrate the FOA's submitted program into an overall Civil Works program which is defended before the Secretary of the Army, the Office of Management and Budget, and Congress. Once the program is finally determined, we work with you to ensure that the resources, both dollars and manpower, are in the right place at the right time.

PRIORITIES OF COASTAL ENGINEERING PROJECTS

The Corps' annual expenditures related to coastal work are small compared to the total Civil Works budget. The priorities of coastal work projects are determined by the benefits derived from the project. Where the coastal work is an integral part of the provision and maintenance of commercial navigation, it is accorded high priority; however, when it is directed primarily toward the provision of recreational opportunities and land preservation, it is accorded a much lower priority.

The Administration's view on coastal projects is that they be given very low priority, especially those associated with recreation or protection of land from erosion. This policy is reflected in several letters (such as the one dated 5 October 1983 (Appendix B)) from the Office of Management and Budget (OMB) to the Assistant Secretary of the Army for Civil Works (ASA(CW)) which advised us that Federal water projects, designed primarily to provide recreational opportunities, are inconsistent with the Administration's budget priorities and the policy of relying on the private sector to provide public services whenever possible.

CURRENT DEVELOPMENT

The ASA(CW) recently pursued the funding policy for coastal engineering projects with OMB. The specific issue was as follows: "If a coastal project is very important to local interests and they are willing to pay a high non-Federal share, can we construct the project?" In the past the ASA(CW), in accordance with basic Administration policy, opposed funding projects that provided primarily recreational benefits. These consisted mostly of beach erosion control and small boat harbor projects. Congressional delegations have voiced strong opposition to this policy, particularly when local sponsors were willing to pay a high non-Federal share of the project and when the project was perceived as economically important to the area. The possible solution recommended was a high non-Federal cost-sharing formula as a measure of a project's importance. This would also be a means of "opening the door" to construction of beach erosion projects.

This proposal was reviewed and discussed at OMB for 3 months. Their response was to maintain the current policy of opposing the funding or authorization of projects that have primarily recreation outputs and to avoid increasing exposure on the budget side due to funding potential projects in this same category.

FUTURE OUTLOOK

This has caused us to take a new look at potential shoreline and beach erosion projects. The new policy, still to be published in an Engineer Regulation, is that the non-Federal share of capital costs shall be costs allocated to causative project purposes, except that all costs assigned to benefits for privately owned beaches or for prevention of land losses will be 100 percent non-Federal. What this means is that shoreline protection projects must be broken down into their flood control, navigation, recreation, prevention of land loss due to erosion, etc., components. The Revere Beach, Massachusetts, beach erosion control project, being included as a new construction start in the fiscal year 1986 Civil Works budget, indicates this new philosophy will work. The project was included in the budget because our documentation showed a substantial flood control component existed which in turn overcame the generally negative attitude of the OMB toward this type of project. This type of analysis is a must if we expect to get coastal engineering projects funded in the future.

My observation of model tests being conducted here at the Coastal Engineering Research Center is that most of the model testing involves coastal port projects with substantial commercial navigation benefits. This type of work continues to be given high priority in the budget process, and once the issue of user fees/cost sharing is resolved it will be doubly important that our solutions be economical and technically correct. I support the continued emphasis on this type of work.

DISCUSSION

PROF. WIEGEL: *I guess it gets into this confusing area of Congress and past administrations having passed all kinds of laws which in some way may be conflicting, for example, the pressure on states as far as coastal zone planning and management are concerned. In California we've got several things going. In Monterey Bay, we're going to commit—in fact, we're already committing—several hundred thousand dollars for next year, and it will be ongoing for 4 years at an increasing rate. We will be looking at a whole bay—the waves, currents, mixing processes, beaches—and how impacts of harbor entrances and so* *forth will affect these. The Federal government has mandated, through a whole series of court actions, certain things which must be done. Now on the other hand, if we do them how are they to be done? And what is the research portion?*

In other words, I'm not talking about building a structure on Presque Isle but the research portion. And if it's decided, which I think in many cases it has to be, the research has to be done full scale. It has to be done at Presque Isle or somewhere similar to it because we've done about as much as we can in laboratories and numerical models, and we have to put these things on the beaches and test them out. Some place, sometime, somebody has to do the full-scale testing. And I just wanted to ask if this is compatible with the present statements made by Stockman's group?

MR. STEINBERG: A short answer would be "no," but let me address some of the points you made. First, after a number of years in Washington, I no longer think the Federal Government or, for that matter, any level of government speaks with a single voice. We know that our view of what the Federal involvement should be is different from that of the Department of Interior. The Office of Management and Budget (OMB) has a big deficit, $200 billion a year, to worry about. So it's too simple to take a signal from one agency or one decree and apply that broadly.

On the other hand, in the budget process we try to focus it down, keeping in mind, however, that we are anxious to support you as best we can. The Repair, Evaluation, Maintenance and Rehabilitation (REMR) Program is a good example of how you can't jump in and shock people with a big new program suddenly. You try to come in and say, "I need these full-scale tests, and I've got to get it done in 2 or 3 yrs; therefore, I need $10 million just for that the first year." The answer is going to be "no," right off the bat. Cecil Goad worked really hard in getting the confidence of our OMB examiners and the big benefits that the REMR program will pay. Also I know Bill Murden, a decade ago, was working with the scientists here at WES. John Harrison and several of his colleagues used to come up to present the benefits of the research program. They built it up gradually over time and said we've got a starting date and an ending date to this research, and we're going to have a useful product at the end. That, too, seems to sell.

I want to pick up on what General Edgar said about getting the committees interested in it. The committees will act--will react rather, to members' concerns and needs. They will not react very often. Occasionally we can ask for favors to his requests or my requests. But if we can adapt this to the members' needs, more specifically, those members on the appropriations committees, we would have a head start on that. And when Ernie made his comment a moment ago, that's what was going through my mind. Dr. Choromokos makes his pitch each year. Does it have any effect on the outside? The best we've been able to hope for, recently, is not to get a cut from the budget, as opposed to additional members, unless the increase can be related to a specific project of a specific mantle. And that's really the challenge.

We invited members of the committee down when CERC was at Fort Belvoir. It was a lot more convenient then. Some have come down here to WES to look at the models, and that needs to be a continuous process. We discussed that this morning at the very fine briefing that Colonel Lee had for us.

DR. LE MÉHAUTÉ: You have mentioned that there is more support for work relating to harbors than for beach erosion, recreation, and so on. Harbor activity was not a mandate of CERC when it was at Ft. Belvoir. Since CERC moved here, the Wave Dynamics group where the harbor activity was done was incorporated within CERC, and in such a way that the activity of CERC has been largely in the direction which seems to be appropriate for requesting more funds. On the other hand, the mandate of CERC has not been changed in the process. It would require an adaptation and modification of the mandate of CERC to include harbor research and by so doing popularize the appropriation of funds by changing a little bit the image of the research being done here.

DR. STEINBERG: Perhaps others would like to comment on that. I think that's a very astute comment, and I made the same observation, mentally, when I went through a number of the models on Monday this week. Doing the harbor work also provides a much broader arena of sources of funds. For example, the funds are coming from construction and operations and maintenance as well as from general investigations, and it's more consistent with the national priorities that we get them from OMB. I think your comment is correct, but others should comment on that.

COL LEE: The comment I wish to make is that CERC is part of the Waterways Experiment Station, an integral part organizationally. When we receive a mission that's within our asking R&D, then we do it with whatever organization or people within WES is appropriate. So that I think it's perfectly all right--proper--for CERC to be doing harbor work, if they're the best people to do it, as opposed to maybe the Hydraulics Lab which might have done it sometime in the past. I'll give the chance to Dr. Whalin, if he wants to add to that.

DR. WHALIN: No, I don't think so. One of the great advantages of our relocation is certainly the compatibility with the other labs at WES. We have a number of projects ongoing with each of the other laboratories at WES, including the Geotechnical Lab, and the Structures Lab. You're going to hear about some of those this afternoon and tommorrow, too. And we interface, of course, with the Hydraulics Lab essentially in the Estuaries Division. The coastal harbors work is done at CERC, and the estuarine and riverine harbors work is done in the Hydraulics Lab. And then the Environmental Lab interfaces with all of us dealing with dredged material and any other environmental concerns.

We do have the opportunity here to form project teams with a total suite of expertise that it would have been impossible to do at Ft. Belvoir. It's difficult to form project teams when you're a thousand miles away. We certainly have the opportunity here, and we're taking advantage of the opportunity to really take a total team approach to the problems that we are confronted with down here within the laboratories.

BG EDGAR: *I wish to ask Colonel Lee and Dr. Whalin—in light of Dr. Le Méhauté's observation (and I certainly agree with Bory, he's right on the mark)—the following question. Given what our focus is at this meeting in trying to define, or perhaps redefine, the charter of our organization, and in light of CERC's new location and its integration into the WES community, couldn't we get some thoughts as to redirection in the harbor area? That kind of thing would certainly seem to be appropriate. If you could put together some mission line bullet type of thing for our discussion later on this afternoon as we develop our thoughts here, that might certainly be reflected as well as any other things that may evolve. Then we have something we can go the the Chief with and say, "Here's the way we see it; recommend you go," and that then gives him the opportunity of saying "yes" or "no."*

COL LEE: Yes, sir, we can have it ready.

PROF. WIEGEL: Let's get it in the record because this corporate memory of mine is overlapping with that of Dean O'Brien who was on the original Beach

Erosion Board (BEB) from the year one. It's my understanding that the reason the original BEB was set up back in the early 1930's had to do with the effects of harbor entrances and structures being placed, such as jetties, on these beaches. It was actually the beach at Santa Barbara. It was a Federal project and in the best public interest to build a breakwater. This interrupted the littoral drift and caused severe erosion down coast. At that time, the law was, "Well, that's just tough luck." This was the start of the BEB which then grew after World War II, and all the military stepped into the situation, but it did start from harbor entrances. And I agree with Bernie and the General that I think it's long overdue to get back into the harbor thing. To me, it is almost unbelievable that in this country, with all of our ports, there's only one course on ports that's given in any university. And that's the one up at the Massachusetts Institute of Technology. This is a major activity in this country, and it's rather surprising to me that we do so little when it has such a big and tremendous economic impact.

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COASTAL ENGINEERING RESPONSIBILITIES OF THE HYDRAULICS AND HYDROLOGY DIVISION

Mr. Vernon K. Hagen, Chief
Hydraulics and Hydrology Division
Directorate of Civil Works
Office, Chief of Engineers

Mr. John H. Lockhart, Jr., Civil Engineer
Hydraulics Design Branch
Directorate of Civil Works
Office, Chief of Engineers

ABSTRACT

Much of the responsibility for coastal design and technical guidance for the US Army Corps of Engineers is located in the Hydraulics and Hydrology Division of the Directorate of Civil Works. Coastal hydraulic design guidance is provided through the issuance and updating of Engineer Regulations, Engineer Manuals, Engineer Technical Letters, and Engineer Pamphlets. Coastal research and development is prioritized, technically monitored, and provided technical guidance. Coastal design training courses and workshops are initiated and/or approved. Reviews of studies, designs, and projects are conducted; and consulting services are provided to ensure technical adequacy.

INTRODUCTION

The Hydraulics and Hydrology (H&H) Division functions under the direction of the Directorate of Civil Works and the Executive Office of the Chief of Engineers (OCE)/Headquarters, US Army Corps of Engineers (HQUSACE). An organization chart of the Division is shown in Figure 1. Our coastal responsibilities are outlined in Office Memorandum 10-1-1 (1 Oct 84). The major portion of these responsibilities resides in the Hydraulic Design Branch under the supervision of Mr. Samuel B. Powell. Our coastal specialist is Mr. John H. Lockhart. Some aspects of our coastal functions are shared within the Division, since coastal work overlaps many other functional areas. Mr. Bruce McCartney is involved with coastal navigation as the navigation specialist. Mr. Ming Tseng is involved with coastal math modeling and coastal stage frequencies as part of his specialty, and Mr. Yung Kuo is involved in getting the coastal sediment studies listed in the annual sedimentation report.

HYDRAULICS AND HYDROLOGY DIVISION
HQUSACE (DAEN-CWH)

CHIEF: VERNON K. HAGEN (202) 272-8500
SECY: Ida S. Battle (202) 272-0228

Hydrologic Engineering Branch (DAEN-CWH-Y)	Hydraulic Design Branch (DAEN-CWH-D)	Water Control/Quality Branch (DAEN-CWH-W)
CHIEF: Roy G. Huffman	CHIEF: Samuel B. Powell	CHIEF: Earl E. Eiker
Shapur A. Zanganeh (Hydroelectric Power)	Bruce L. McCartney (Navigation)	Eugene A. Stallings (Water Control, PMF, SPF, Dam Safety)
Yung H. Kuo (Potamology/Sedimentation)	John H. Lockhart (Coastal)	Ming T. Tseng (Systems Modeling, Coastal)
Lewis A. Smith (Flood Control)	Thomas E. Munsey (Flood Control)	Buford D. Wingerd (Cooperative Stream Gaging, AFOS)
		Lynn M. Lamar (Biologist)
	SECRETARY: Darlene P. Savoy	(202) 272-0224

FIGURE 1. ORGANIZATION CHART

POLICY AND GUIDANCE

We, as a Division, formulate and issue technical policy and guidance for the application of hydraulic, hydrologic, and coastal engineering and water control management in the planning, design, construction and operation of Civil Works and other assigned Federal programs. This is a critical element of our responsibility. It is accomplished by issuing official Corps of Engineers (Corps) publications in the form of Engineer Regulations (ER's), Engineer Manuals (EM's), Engineer Technical Letters (ETL's), and Engineer Pamphlets (EP's). As a brief explanation, ER's are directive in nature. They identify requirements. EM's are explanatory in nature. They provide technical guidance on how to accomplish requirements. ETL's are informative in nature. They provide advance information related to design, engineering, and construction. EP's contain information guidance or reference material of a continuing nature, such as indexes to regulations.

The Hydraulic Design Branch was the first branch in the Division to establish a publication plan. Its objective is to guide R&D and funnel technology transfer into the OCE publications to ensure that the field offices are provided modern up-to-date guidance. The Coastal Engineering Publication Plan is listed in Table 1. As indicated in the Scheduled Revision or Publication Date column, we will be busy for the next few years updating and modernizing our technical guidance through the publication of 11 new or revised EM's.

REVIEW

The coastal engineering aspects of studies, criteria, investigations, and projects are reviewed to ensure compliance with established policy and guidance. Every engineer has the right to at least one independent review of his design (preferably two). This practice has built the reputation of reliability and quality of the Corps of Engineers. We attempt to preserve this practice through our reviews of feasibility and design reports. Frequently we refer design reports to the Coastal Engineering Research Center (CERC) for a second independent review. We also usually confirm that the Board for Rivers and Harbors (BERH) has provided CERC with copies of beach erosion control feasibility reports for review at the same time we review them in H&H.

TABLE 1
COASTAL ENGINEERING PUBLICATION PLAN

Title of Publication	Scheduled Revision or Publication Date	Point of Contact	Author	Actual Publication Date
		ENGINEER REGULATIONS		
ER 1110-2-8151 Monitoring Coastal Projects				8 Apr 81
ER 1110-2-1406 Coastal Field Data Collection				30 Sep 82
ER 1110-2-1407 Hydraulic Design for Coastal Shore Protection (20 Jan 84 - Change 1)				30 Jun 83
		ENGINEER MANUALS		
EM 1110-2-1607 Tidal Hydraulics				2 Aug 65
EM 1110-2-2904 Design of Breakwaters and Jetties (CH 1-4)	1985	Davidson CERC	Carver CERC	30 Apr 65
EM 1110-2-3300 Beach Erosion Control and Shore Protection Studies (CH 1)	1987	Camfield CERC	May CERC	31 Mar 66
EM 1110-2-1614 Design of Coastal Revetments, Seawalls, and Bulkheads		Lockhart OCE	Lesnik Contractor	30 Apr 85
EM 1110-2- Coastal Project Monitoring	1986	Garcia CERC	Hemsley CERC	New
EM 1110-2- Water Levels and Wave Heights for Coastal Design	1985	Camfield CERC	Thompson CERC	New

(Continued)

TABLE 1 (Continued)

Title of Publication	Scheduled Revision or Publication Date	Point of Contact	Author	Actual Publication Date
EM 1110-2- Littoral Transport Estimates for Coastal Engineering	1987	Camfield CERC	CERC	New
EM 1110-2- Design of Beach Fills	1986	Camfield CERC	Hands CERC	New
EM 1110-2 Sand Bypassing Systems	1987	Camfield CERC	Clausner CERC	New
EM 1110-2- Design of Coastal Groins and Nearshore Structures	1986	Camfield CERC	Pope CERC	New
EM 1110-2- Coastal Inlet Hydraulics and Sedimentation	1987	Camfield CERC	Weishar CERC	New
EM 1110-2- Coastal Storm Surge Analysis	1985	Tseng OCE	Bodine SWD	New
ENGINEER TECHNICAL LETTERS				
ETL 1110-2-213 Vertical Wall Break-waters--Wave Transmission				5 May 76
ETL 1110-2-233 Hydraulic Model Tests of Toskane Armor Units				30 Jun 78
ETL 1110-2-242 Stability Coefficients for Placed Stone Jetties				2 Apr 79

(Continued)

TABLE 1 (Concluded)

Title of Publication	Scheduled Revision or Publication Date	Point of Contact	Author	Actual Publication Date
ETL 1110-2-273 Design of Floating Breakwaters				21 Jun 82
ETL 1110-2-288 Floating Breakwater Prototype Test				31 Aug 83
ETL 1110-2-291 Low-Crest Breakwater Design				17 Oct 83
ETL 1110-2-292 1983 Coastal Engineering Hydraulic Design Conference				29 Feb 84
ETL 1110-2-293 Entrance Channel Infill Rates				15 Mar 84
ETL 1110-2-305 Determining Sheltered Water Wave Heights				16 Feb 84

TRAINING

We initiate and approve training programs containing coastal hydraulic engineering information. Two coastal engineering courses are normally conducted by CERC each year.

In addition, special courses, workshops, and design conferences are conducted. Special courses focus on particular areas of design, such as jetties and breakwaters. Design conferences are broad in nature, such as the 1983 Coastal Engineering Hydraulic Design Conference held in Jacksonville, Florida. For the design conference, all the coastal Districts were canvassed for topics of discussion and requested to present their problems. Representatives of CERC provided state-of-the-art responses which were followed by a brief general discussion. Special courses, workshops, and design conferences are well received by field personnel. The design conference format also provides a means of identifying areas needing R&D efforts.

CONSULTING

The H&H Division provides or assists in obtaining coastal engineering consulting services for other Headquarters offices, the BERH, Field Operating Agencies, other government agencies, and foreign governments. We routinely provide services to Corps agencies; however, our activities outside the Corps in recent years have been limited to identifying individuals or Corps offices with the needed skills.

TECHNICAL MANAGEMENT

Research and Development

We monitor and provide technical supervision over flood control, navigation, and coastal hydraulic research and development (R&D) at Corps laboratories. The technical monitors participate in the annual R&D program reviews. They are routinely informed of necessary changes in progress on individual work units. The coastal technical monitor attends all the Coastal Engineering Research Board meetings to ensure that the R&D program is meeting the important needs. Technical monitors review the semiannual progress reports. Through their familiarity with field needs and R&D capabilities they are able to work closely with the laboratories to set priorities and direct R&D efforts. Since we are also responsible for technical policy and guidance in these areas, the technical monitors are able to direct R&D products into OCE policy and guidance as illustrated in the following sample of work unit documentation (Figure 2).

Hydraulic and Hydrologic Studies

A wide variety of highly specialized hydraulic and hydrologic studies is required for the planning, design, construction, and operation of Corps projects. Many of the studies are beyond the normal capabilities of the District or Division staff. The unique nature and expert staff requirements of many of these studies have led to the development of a number of specialized hydraulic-hydrologic facilities within the Corps, such as CERC. These

COASTAL STRUCTURE EVALUATION AND DESIGN

WAVE RUNUP AND OVERTOPPING
WORK UNIT NO. 31229

PROBLEM:

LACK OF KNOWLEDGE ABOUT RUNUP AND OVERTOPPING BY NATURAL WAVE CONDITIONS MAKES IT DIFFICULT TO OPTIMIZE THE DESIGN OF COASTAL STRUCTURES.

OBJECTIVES:

TO DEVELOP DESIGN CURVES, TABLES, AND COMPUTER PROGRAMS RELATING RUNUP ELEVATIONS AND OVERTOPPING RATES TO THE CHARACTERISTICS OF THE WAVES AND STRUCTURES.

MILESTONE:

(A) MP/ETL, STATE-OF-THE-ART OVERTOPPING RATES, MARCH 1985

(B) PROGRESS REPORT ON MONOCHROMATIC WAVE OVERTOPPING RATES FOR SELECTED REVETMENT/SEAWALL COMBINATIONS, JUNE 1985

(C) MP/ETL BEACH RUNUP, JUNE 1985

(D) PROGRESS REPORT ON OVERTOPPING RATES FOR SELECTED REVETMENT/SEAWALL COMBINATION, SPECTRAL WAVES, DECEMBER 1985

(E) PROGRESS REPORT/ETL ON OVERTOPPING RATES ON STEEP RIPRAP REVETMENTS, SEPTEMBER 1986

(F) UPDATE INFORMATION FOR EM's, SPM, AND TRAINING COURSES

FIGURE 2. SAMPLE COASTAL R&D WORK UNIT SUMMARY

facilities are to receive preferential consideration when District or Division studies are to be accomplished other than in-house. The H&H Division approves all contracted H&H studies which exceed $50,000 in costs, except for physical hydraulic model studies which must exceed $100,000. Studies of lesser scope are approved by Divisions except New England and Pacific Ocean Divisions, for which OCE acts as the Division. Monthly progress reports on each study are provided to the sponsoring field office, with information copies to the H&H Division. Through this procedure, we are able to better ensure the technical competence of the studies, monitor their progress, and aid the field in problem areas.

Programs

The H&H Division acts as the proponent for the Coastal Field Data Collection (CFDC) Program and the Monitoring of Completed Coastal Projects (MCCP) Program. The CFDC Program has as its objective the systematic acquisition of necessary long-term coastal data required for modern coastal studies and designs. There are seven subitems in the program:

(1) Wave gaging.

(2) Wave information studies.

(3) Visual surf and nearshore current data.

(4) Beach, dune, and nearshore profile data.

(5) Hurricane surge data.

(6) Coastal imagery data directories.

(7) Coastal sediment surveys.

Only the first four are proposed for funding in fiscal year 1986

A selective and intensive monitoring of Civil Works coastal projects is carried out under the MCCP Program. Projects that provide the maximum quantity and quality of applicable data addressing predominant coastal engineering problem areas are identified. Those that best address high-priority problems are selected for monitoring and evaluation. The intensive data base is analyzed, and the prototype results are compared with the preconstruction predictions to verify or upgrade existing design guidance, minimize operation and maintenance cost, and assure project-formulated benefits.

We provide staff supervision and management of the programs. This generally involves preparing budget justifications, making fund allocations or cuts, corresponding with the field and CERC, and providing guidance and general direction to the programs. CERC provides technical and management support for the programs.

Committees

We also provide staff supervision and management of the Committee on Tidal Hydraulics, the Committee on Channel Stabilization, and the Committee on Water Quality. In the coastal area the Committee on Tidal Hydraulics maintains a continuing evaluation of the tidal hydraulics state of the art, identifies problem areas, recommends means to provide improved techniques, and disseminates pertinent information. The Committee also provides consulting services on specific problems as may be requested by various elements of the Corps.

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COASTAL ENGINEERING RESPONSIBILITIES OF THE ENGINEERING AND CONSTRUCTION DIRECTORATE

Mr. Lloyd A. Duscha, Deputy Director
Directorate of Engineering and Construction
Office, Chief of Engineers

ABSTRACT

The Engineering and Construction Directorate is engaged in the formulation and management of engineering and construction guidance for various types of coastal engineering structures ranging from jetties and breakwaters to beach restoration. The Geotechnical and Structures Branches of the Engineering Division and the Planning and Engineering Support Branch of the Construction Division continue to support Corps of Engineers (Corps) Divisions and Districts in new and innovative investigations, design, and construction practices. Those efforts, in cooperation with the Civil Works Directorate and Corps laboratories, are producing technically sound, cost effective, environmentally acceptable projects in our coastal areas.

INTRODUCTION

The engineering responsibilities of the Engineering and Construction Directorate for coastal projects include providing technical management and review; providing consulting services to Field Operating Activities; formulating technical guidance; managing and overseeing research and development in new, innovative concepts; and developing technical training programs. These activities are pursued during all phases of project development ranging from initial feasibility studies through advance design and construction. Engineering responsibilities are resident in the Structures and the Geotechnical Branches of the Engineering Division, which coordinate with the Hydrology and Hydraulics Division of the Civil Works Directorate where technical overlap exists. Construction responsibilities of the Directorate reside in the Construction Division and are similar to those performed for other noncoastal Corps of Engineers (Corps) projects, i.e., construction management, contract administration, and monitoring quality assurance and quality control activities. The Directorate is also responsible for project safety.

STRUCTURES BRANCH

The Structures Branch of the Engineering and Construction Directorate has the technical management responsibility for design of coastal structures. Their primary interest has been with seawalls, hurricane protective walls, bulkheads, concrete portions of breakwaters and jetties, and construction and repair of lighthouses. Admittedly, we don't get called to build many lighthouses nowadays, but we recently restored one at Bandon, Oregon, and we performed the design for the protective works at the historically significant lighthouse at Cape Hatteras, North Carolina.

This branch is presently revising the Wall Design Manual which contains the criteria for design of hurricane protection walls. It is expected to be released to the field offices in 1986.

Rubble-Mound Breakwaters

With the very tight federal budget and the expected requirement that a greater share of projects will require local funding participation, there is an increasing need to use innovative design for greater economy. The traditional rubble-mound breakwater designed with conservative sideslopes is a very expensive structure. With the exception of the Pacific Northwest, large jetty stone (25-ton) is increasingly difficult to find within an economic hauling distance to a project. However, concrete armor units can be cast anywhere, and they are much more efficient than natural stone. The most widely used armor unit is the dolos. It is shaped somewhat like a ship's anchor. Dolosse have been used at Humboldt Bay and Crescent City, California; Manasquan, New Jersey; Cleveland Harbor, Ohio; and at several projects in Hawaii. We expect to use them at Oregon Inlet, North Carolina. At every project using dolosse the question always arises whether to reinforce the units or not. For example, at Oregon Inlet, it would cost an additional $11 million just to add reinforcing. Another problem is that no one knows the forces actually imposed upon dolosse. Consequently, there are no mathematical or physical models which can be used to design more structurally efficient units. To investigate and mitigate this problem, we are presently in the early stages of a $2 million research program at Crescent City in which we are instrumenting 42-ton dolosse in order to secure data which can verify our experimental models. We believe this research effort will provide better criteria for future designs of concrete units.

Floating Breakwaters

Another substitute for the rubble-mound breakwater is the floating breakwater. We have recently completed a $2.1 million prototype test program in Puget Sound that tested two concrete floats and one pole-tire breakwater structure. The tests were very successful, and we have already saved two-thirds of the cost of the test program through better designs at other projects in the Puget Sound area. Although substantial savings are predicted, there appears to be a natural reluctance to accept something not having the appearance of mass.

Concrete Sheet-Pile Breakwaters

Another innovative breakwater has been designed for use at Fisherman's Wharf in San Francisco. This project is composed of a ring of concrete sheet piles with gaps to allow for circulation of water into the sheltered area. The design is quite challenging, as the project is located in a strong seismic area, in water depths of 60 ft or more, and will be driven in very deep accumulations of soft bay mud. The economics provided by innovative design are demonstrated by a somewhat similar design in much shallower water recently completed at Bodega Bay, California. The local authority has decided to fund and build the project themselves using the Corps design.

Because of the large quantities of concrete that the Corps uses in coastal projects, we have been testing sample sections of various types of concrete beams, including prestressed units, at our exposure test site at Treat Island, Maine. The samples are subjected to alternating periods of submergence and surface exposure twice a day. Periodically, sample beams are returned to the Concrete Laboratory at the US Army Engineer Waterways Experiment Station to be analyzed. These data have been shared with the American Concrete Institute (ACI). The Corps is represented in the ACI by some of our employees who are members of the ACI subcommittee which is involved with concrete exposure technology.

GEOTECHNICAL BRANCH

The Geotechnical Branch has the oversight responsibilities for those management areas described in my introduction as they relate to geology and soils and materials engineering. This branch maintains a relatively close association with current coastal projects through strong professional ties with the geotechnical community in Division and District offices, and by assigning a member of the branch staff to oversee all geotechnical areas regarding coastal engineering ranging from review of current projects and research and development activities to training development for geologists and geoengineers.

Engineering activities performed by the Districts on coastal projects include foundation studies; investigation of material sources for beach sand replenishment and stone jetty construction; investigation of existing structures requiring the use of drill rigs; and performing geomorphological studies on large, regionally oriented projects where the interaction between long-term coastal processes and project performance is necessary to accomplish cost effective, environmentally suitable designs.

Coast of California Storm and Tidal Wave Study

Several projects located on both coasts serve to illustrate the increasing need for geotechnical input to coastal engineering projects, and the District/Division response to those needs. The Coast of California Storm and Tidal Wave Study is such a project. This project stretches from the Mexican border to the Oregon state line and is divided into a number of major study units. It was recognized by the geotechnical representatives in the South Pacific Division that the geological complexities of the various studies made it imperative that a systematic evaluation of the geologic factors at work in the coastal zones be made of each study section. The first study to effectively characterize the geological environment of the southern California coast is titled "Geomorphology Framework Report--Dana Point to the Mexican Border." This study was completed in 1984, and it provides basic data about the coastal physiography, the physical properties and erosional rates of sediments supplying the coastal zone, and the nature of the longshore transport mechanisms moving those sediments. All these data, provided early in the overall study, will be used as guidance by planning and technical personnel in executing and completing subsequent project tasks. Because of the apparent success of this study in Southern California, each of the major study units along the California coast will contain a geomorphology framework study.

Atlantic Coast of New Jersey-Sea Bright to Sandy Hook Project

Another coastal project where a significant geotechnical input is required is the Atlantic Coast of New Jersey-Sea Bright to Sandy Hook Project. This project is primarily oriented toward hurricane protection and beach restoration of the affected areas. This portion of the Atlantic coast has had a long history of beach deterioration and ineffective coastal protection structures. As one of the major factors creating the coastal problems in this area, the geological processes currently at work are poorly understood, both in short- and long-term modes. Like the geological study requirements of the coast of California study, the New Jersey coast needs to be systematically characterized in geotechnical terms. These needs require addressing early in the study, and to accomplish this, the District performing the study has been requested to expand its geotechnical studies to include a regional framework geomorphological study of the project area.

Oregon Inlet, North Carolina, Jetty Project

Although geomorphology oriented studies are relatively new requirements for Corps coastal engineering projects, there remains a strong need for evaluating and upgrading traditional current geotechnical investigation procedures in our Districts. The Oregon Inlet, North Carolina, jetty project is a case in point. Where past procedures for investigating jetty foundation conditions in the surf zone were minimal to nonexistent or relied on extrapolating geologic information from the beach seaward, the implied existence of a low strength bearing zone in the foundation required the District to eventually perform at Division direction, subsurface explorations in the surf zone along the jetty alignment. This study was made at considerable cost. The net result of this was the need to drastically change the jetty structural design during the middesign engineering phase in order to make the structure stable, delaying the project significantly. The message here is that the entire investigation for design purposes must be total and complete, and the managers and review authorities must be constantly alert to possible engineering deficiencies on our projects, whether geotechnical or some other discipline.

SUMMARY

The Engineering and Construction Directorate continues to play a strong and leading role in the design and construction of coastal projects. This Directorate, working in harmony with the Hydrology and Hydraulics Division of the Civil Works Directorate, will continue to develop the design and construction guidance needed for innovative, economical, and safe structures using the findings of research and development.

DISCUSSION

PROF. WIEGEL: I know we're trying to keep on schedule, but there are problems with the materials and concrete you mentioned such as whether to reinforce or not to reinforce, and there are some new things being put into the concrete to decrease the porosity which is apparently a much better concrete. But there's a whole new class--or new to civil engineers, not new to others--called composite materials. And of course, concrete is a composite material, but I'm thinking of the other ones used by the aerospace people. Somehow, it seems to me that we in civil engineering are just not up to the mechanical engineers in looking at materials as an integral part of our teaching process. When the engineers come out and you people hire them, they haven't anywhere near an adequate background in materials.

And this worries me basically about the whole way that you're set up here for research and we're set up in universities for research. I'm not pointing the finger at anybody. We all have the same problem involving hydraulic foundations and concrete. No project is like that. A project has a foundation. You have to worry about the geology; you have to worry about the materials; you have to worry about the constructability; you have to worry about the maintenance. And I'm just wondering whether or not we should be restructuring in engineering as a whole--and especially in civil engineering--how we set up to do our research and our planning.

MR. DUSCHA: Well, I think that's a good point. I think if you look at the engineering process or engineering education, everybody gets a little bit of this and little bit of that. But we never try to put together how this develops a product. This is probably something that's missing. And so I think what this tends to do then is to have everybody cast in his own mold, looking at his own thing, perhaps, and forgetting about what may affect that thing. I think we could develop better synergism from here than we have.

COL HANSON: I am Wayne Hanson, Wilmington District Engineer, and Oregon Inlet is my responsibility. As far as your comment about the floating breakwater is concerned, I think there is opportunity in Oregon Inlet if we could build a full-scale model or full-scale concrete barge for our sloping float breakwater. One of the allegations about Oregon Inlet is that the sloping float breakwater won't work.

That same technology is also used to protect beaches during or after amphibious landings. That's the reason the Navy got involved in it. I know that CERC is looking for military work, and that might be an opportunity.

BG EDGAR: Wayne, that's a very good point, and I think we need to pursue that further in the discussion later this afternoon.

COASTAL ENGINEERING RESPONSIBILITIES OF THE OPERATIONS AND READINESS DIVISION

Mr. Cecil G. Goad, Chief
Operations and Readiness Division
Directorate of Civil Works
Office, Chief of Engineers

ABSTRACT

The major coastal engineering activities of the Operations and Readiness Division involve breakwater repairs, entrance channel dredging, limited beach nourishment associated with adverse navigation project impacts, flood fights, rehabilitation of Federally authorized and constructed beach erosion control and hurricane projects, as well as some regulatory functions pertaining to work in navigable waters or discharge of material in a United States water. To accomplish vast and expanding responsibilities in these areas, several research projects are under way to help control costs while enhancing project benefits and extending the life of the projects.

OPERATIONAL ACTIVITIES IN PROJECT OPERATIONS AND MAINTENANCE

Coastal engineering is involved in several major aspects of Project Operations and Maintenance (O&M): breakwater repair, entrance channel dredging, and limited beach nourishment associated with adverse navigation project impacts. Additionally, a minor amount of sand bypassing, as a least costly channel maintenance alternative, is accomplished under Project O&M.

Dredging

Dredging activities, exclusive of building and maintaining disposal areas, require more than 30 percent of Project O&M resources and, therefore, generate considerable interest from the Administration as well as industry. We can normally anticipate dredging an average of 250 million cubic yard at an average annual cost of $400 million.

As the largest portion of our dredging is accomplished along the coastal region and there are no good statistics on the subject, there is much concern as to the best means of keeping bar/entrance channels clean as well as the best means of disposing of vast quantities of dredged material. The current policy regarding dredged material disposal is predicated on cost effectiveness. As this policy relates to beach nourishment, an area of your concern, disposing of dredged material may be an indirect way to nourish beaches if cost effective; or it may be a direct way to nourish the beach if local interests agree to pay for any incremental costs for disposal on their land.

Sand Bypass Systems

There have been at least four sand bypass systems employed in the past to keep entrance channels clean and simultaneously dispose of material on shore: Palm Beach Harbor, Florida; Rudee Inlet at Virginia Beach, Virginia; Santa Cruz Harbor, California; and at several sites in Michigan where a portable, trailer-mounted system was tested. All proved to be costly and less effective than other means of dredging and disposal. Only the system used at Palm Beach Harbor is still in use at 100 percent local cost by Palm Beach County. It is used to replenish sand during the winter season. The Michigan trailer-mounted system may be used soon at Duluth Harbor to redistribute fill at the disposal site.

Today the South Pacific Division is constructing an experimental sand bypass system at Oceanside Harbor, California. World War II construction of harbor-associated features at Camp Pendleton and the subsequent completion of the City of Oceanside's Small Craft Harbor resulted in continuing, large annual maintenance dredging requirements in the combined entrance channel. At the same time the downcoast recreational beaches of Oceanside have been repeatedly eroded, and it is widely held that the harbor construction is at least partially responsible. Congress in 1982, therefore, authorized an experimental sand bypassing system which would have the dual purpose of reducing channel maintenance and of providing sand to nourish downcoast beaches. The total project envisions the installation of ten jet pumps at the south jetty, two additional jet pumps and three fluidizers at the seaward end of the north breakwater, and a single jet pump located in the north fillet area. These will be supported by a mobile pumping unit mounted on a jackup barge, a booster pump station on shore, and a 10,800-ft-long discharge line extending along the beach from the south jetty. As each phase of design and construction is finished, performance and cost effectiveness will be evaluated prior to proceeding to the next phase. Construction should be completed by mid-1986 with initial operation now scheduled for July 1986.

The project at Oregon Inlet, Manteo (Shallowbag Bay), North Carolina, if ever constructed, authorizes sand transfer to downdrift beaches. An economical means of accomplishing this purpose will be studied.

Breakwaters

Breakwaters represent a large investment for the Corps in numbers of projects and resources spent or to be spent. There are 634 major breakwaters at 334 major navigation projects for which the Corps is responsible. To replace these breakwaters using present-day stone technology would require an investment of $5 billion, so you can appreciate our interest in maintaining these structures to obtain prolonged, maximum benefits.

Of these major breakwaters, 76 percent are stone; 17 percent are timber crib (predominantly in the Great Lakes region); and the remaining, in descending order of magnitude, are steel sheet-pile cell, concrete caisson, concrete armor, wood pile wall, steel sheet-pile wall, steel sheet-pile bin, concrete wall, sand, floating, concrete crib, and concrete gravity.

We are especially concerned about our breakwater projects. This year we initiated a $39 million major rehabilitation program at three Great Lakes harbors (Duluth-Superior, Milwaukee, and Cleveland), and we have many more requests for rehabilitation of breakwater projects.

We are involved with dolosse. This type of breakwater armor structure is exceedingly effective, but the dolosse have historically sustained rapid breakage. Only recently has the state of the art improved to allow us to conduct a prototype stress measurement study now scheduled to be accomplished at Crescent City Harbor, California.

Measurements will be taken at prototypes to provide boundary conditions and verify finite element structural models of dolosse. Results from these measurements and modeling will be used to develop structural design criteria for dolosse, thus reducing breakage rates, lengthening time intervals between major maintenance, and, hopefully, saving millions of dollars in future maintenance costs of breakwater projects using dolosse.

Mitigation of Shore Damages

When Corps-constructed project features contribute to shore damages, we have general authorization to investigate cost-effective means of mitigating such damages under Section 111 of PL 90-483. This generally involves consideration of renourishing the shore, but sometimes we construct groins. The North Central Division (NCD), with the largest active mitigation program, had used the trailer-mounted sand bypass system for this work, but as with other Corps elements, NCD found it to be more economical to truck-haul on-land borrow. New navigation projects, however, are formulated giving full consideration to any adverse impacts that might be caused by beach erosion and allow mitigation costs to repair such erosion to be included in project construction and maintenance. One question we must answer regarding mitigation projects revolves around the potential imposition of user fees. Some mitigation is mandatory; some is voluntary. Will navigation users agree to pay these costs, especially in view of the fact that some older projects do not carry this burden?

Beach Nourishment

Beach nourishment as a project purpose is only part of the authorizing legislation for four projects the Corps operates and maintains: Waikiki, Hawaii; New Buffalo, Michigan; and Oceanside and Santa Cruz Harbors, California. As mentioned earlier, disposal of dredged material at other locations may be accomplished if it is the cost-effective means or a local sponsor agrees to pay any added incremental cost of disposing material on a particular beach. This year the Jacksonville District has employed both reasons for disposing on beach land: cost effective at Ponce de Leon Inlet, Baker's Haulover Inlet, and Palm Beach Harbor. Jacksonville District also had a situation where, in a way, both reasons applied. At Jacksonville Harbor, dredged material is normally disposed on land, but Duval County agreed to pay the added incremental cost of disposing of material half a mile from the intended disposal site. Using beaches for disposal sites will be included in two planned dredging contracts on the Gulf Coast side of Florida.

Here too we must ask questions in view of the potential imposition of user fees: Should the Corps change its policy of requiring incremental, non-Federal financing to place dredged material from a navigation project on a beach when there is another less costly disposal alternative? Should bypass systems be used to maintain harbors even at increased costs when navigation projects have been determined to cause increased erosion?

Research Efforts

We must be responsive to managing an increasingly old infrastructure within limited resources. To do this for coastal engineering projects, we have supported two major research and development efforts: Monitoring of Completed Coastal Projects and Repair, Evaluation, Maintenance, and Rehabilitation (REMR).

O&M sponsored research efforts began in fiscal year 1978 to monitor Civil Works coastal projects to acquire information to improve project performance, design guidance, construction methods, and O&M techniques. Structural, topographic, and hydrodynamic responses and comparisons of projects are analyzed to validate preconstruction predictions, verifying or upgrading existing design guidance; to minimize O&M costs; and to assure project formulated benefits. This national project monitors, evaluates, and documents the performance of selected projects to solve or mitigate major coastal problems. Mr. Vernon Hagen, Chief, Hydraulics and Hydrology Division, will be reporting to you in more detail the results of our efforts to date.

The REMR program is a 6-year, $35 million research program which is now in its second year. The overall objective of the program is to identify and develop effective and affordable technology to maintain and, where possible, extend the service life of existing Corps Civil Works projects. Fifty-two work units are currently being conducted under five primary research program areas: concrete and steel structures, geotechnical, hydraulics, coastal, and electrical and mechanical. The capability to continue to use existing structures safely well beyond their original life expectancy with a minimum expenditure of resources will be the most significant direct benefit from this research program. Even for major rehabilitation projects, costs are usually orders of magnitude less than the replacement cost of the structure. This will result in savings for the government and for users of the structures if increased user fees are implemented. Additional savings should accrue from using proven REMR techniques in the field rather than using untested or inappropriate approaches.

PERSPECTIVE ON EMERGENCY COASTAL ACTIVITIES

Authority

The Corps authority for emergency flood and coastal protection is Public Law 84-99. Although normally applied to emergency activities for riverine flooding scenarios, there are some applications of this authority to coastal storm emergencies. Historically, we have pursued advance measures, flood fight, and rehabilitation activities in coastal areas as dictated by the prevailing circumstances.

Advance Measures

Advance measures are those temporary emergency construction activities which can be effected prior to an imminent flood event as predicted by a forecast by National Weather Service or other reliable source. We have used this authority extensively in coastal areas around the Great Lakes in the past and are involved in a similar situation this year as Lakes Erie, Huron, and St. Clair are rising to near record levels. Typically we have constructed rock cribs or similar temporary seawall or revetment structures to help prevent coastal flooding and erosion in these areas. For instances such as these, there is a need for coastal engineers to develop innovative and effective techniques for expedient coastal protection.

Flood Fight

The Corps emergency authority under PL 84-99 provides District Commanders with authority to flood fight to the degree feasible where severe coastal storms are threatening life and property in highly developed areas. Flood fight opportunities are usually very restricted, however, due to the adverse working conditions and impracticality of rapid, expedient construction along a large reach of coastline with little advance warning. Where practical, these activities can include adding rock protection to protect seawalls or other structures, building temporary sandbag "dunes," or similar temporary actions.

Rehabilitation Works

The law specifically limits rehabilitation work to Federally authorized and constructed beach erosion control and hurricane protection projects. Rehabilitation of these Federal shore protection works is limited to those necessary to reduce the immediate threat to life and property or for restoration to "prestorm" conditions, whichever is less. The storm damage must be supported by adequate "prestorm" condition information. Our major area of concern here is the problem of expediting our emergency response in the rehabilitation of eligible shore protection/hurricane projects. Structural damages can be easily surveyed and clearly qualify for rehabilitation under PL 84-99. However, beach losses present a much more complex problem. In order to determine the costs of beach restoration work, the District Commander must first determine which losses can be attributed to the storm and which are attributable to normal erosive processes. Only those damages caused by storm can be restored by using emergency funds. In those cases where periodic beach nourishment is already scheduled under the authority but emergency work is required, an immediate technical evaluation is made to determine the minimum beach section required to ensure project viability until the scheduled nourishment can be performed. The challenge in the area of coastal emergencies is to develop an expedient survey technique to effect pre-storm survey of coastal beach conditions at a minimum cost but with a degree of accuracy that allows the Federal funding determination to be made quickly and with acceptable risk.

REGULATORY PROGRAM IN COASTAL AREAS

Authority

The Corps regulatory authorities under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act have caused the Corps to evaluate projects which impact coastal areas. Any structure or work in a navigable water or discharge of dredged or fill material in a water of the United States requires a Corps permit. Our procedures require the balancing of many factors in determining if a project would be contrary to the public interest. As part of this review, we apply state-of-the-art knowledge of coastal engineering to appropriate projects. This review is normally carried out within the District regulatory branch which is staffed with both professional scientists and engineers. When regulatory expertise is insufficient, regulatory personnel coordinate with the Engineering Division's coastal experts. We have no specific regulatory policy directly related to coastal development as, for example, we have for wetland development.

Permit Process

Within the framework of our regulatory authorities we strive to minimize duplication with state and local regulatory programs. Wherever possible we develop joint procedures to speed the processing of permit applications. In addition we issue regional general permits to cover activities which are minor and which cause no cumulative adverse impacts. These regional general permits, are shaped wherever possible, around existing state or local regulatory programs. We have no regulatory authority in upland areas and support the primacy of state and local governments in land use control.

In those states which have an approved coastal zone management program, the responsible state agency must make a determination of whether the proposed project is or is not consistent with the approved coastal zone management plan. If the state determination is that the project is not consistent with their approval plan, the Corps permit is denied without prejudice to the applicant. This means that, if the applicant can resolve the state's concern, he may request his application be reopened and reevaluated.

The Corps could choose to develop regulatory criteria through the normal rule-making process to develop definitive guidance on beach erosion and other coastal engineering control works. Such criteria would naturally be limited only to those areas under our regulatory jurisdiction. We have not chosen to attempt to develop such criteria.

CONCLUSION

Our efforts in operating and maintaining coastal projects are vast and becoming more extensive as project structures age and our areas of responsibility increase. We are, therefore, making investments under the O&M program in several research efforts to help control costs while enhancing project benefits and extending the life of the project. We need research, good technical advice, and enlightened management techniques to manage the Corps' O&M program. We believe that CERB can help us through its expertise.

DISCUSSION

PROF. WIEGEL: *I think this ties in with an earlier presentation on the budget about the regulatory permit authority. How much thought is given on the portions of the research programs in order to build up the capability of being able to grant permit authority based upon continually better technical input?*

MR. GOAD: A great deal of thought has been given to some of the aspects of the regulatory program, such as a determination of jurisdiction and a definition of wetland. A great deal of agony and thought are going into some accumulative impacts of some of the things involved in the program like bottomland hardwood conversions and those types of things.

Generally, though, the direction in which the regulatory program is going, is leverage on the activities by others: issue general permits to the extent you can; regulate on the side of leased regulation wherever you can; protect the environment without stifling development to the extent you can; and make it more efficient rather than building it bigger.

Our Branch Chief is great at that. That thing costs $51 million a year, and he won't let us put any more than that in it because he thinks we can do the job more efficiently that way. That's kind of tiptoeing around it. The permit doesn't work the structures, but we do; and we can do research on prototypes of things.

COASTAL ENGINEERING RESPONSIBILITIES OF THE OFFICE OF POLICY

Mr. Alex Shwaiko, Chief
Office of Policy
Directorate of Civil Works
Office, Chief of Engineers

Presented by Mr. Donald B. Duncan

ABSTRACT

The functions of the Office of Policy relating to Corps of Engineers coastal engineering activities are presented in brief fashion. Also discussed is the coordination of efforts among this agency and other governmental agencies.

INTRODUCTION

I am Donald Duncan, and I appreciate the opportunity to brief you on our responsibilities in the Office of Policy relating to the Corps of Engineers' (Corps') coastal engineering program. The Office of Policy performs four functions of interest to you which I will explain briefly.

RESEARCH COORDINATION

Our Research and Interagency Coordination Group carries out several research and development activities. It performs the user representative function for the Civil Works Directorate. The user representative in each directorate is responsible for developing user requirements for research and development and assigning priorities for research effort. The users we represent, for all practical purposes, are the Corps field offices--the Divisions and Districts who experience practical problems and use research and development (R&D) products that are intended to respond to those problems. Our user representative duties also include coordinating the activities of the directorate's technical monitors--who, for the coastal engineering research area, are John H. Lockhart in the Hydraulics and Hydrology Division and John Housley in the Planning Division--and keeping track of the process of technology transfer of R&D products from labs to users. All of us in the Office of Policy act as eyes and ears for the Civil Works Directorate, in our various contacts with field people, to help us initiate steps to improve the effectiveness of the Corps' R&D program to respond to user needs. This personal contact supplements the more formal attendance at R&D program review meetings and sampling of R&D products to achieve the same purpose.

The user representative function includes participation in administering the Civil Works R&D research needs system. This system is the primary--and most formal--mechanism for conveying field perceptions of research needs to research-performing elements. It is supplemented, of course, by contacts among field personnel, technical monitors, and lab personnel, which we encourage. Mission problem statements, which describe research needs, form one of the most important bases for formulating R&D work units and keeping track--in a rough way--of how successfully field R&D needs are being met.

You may have noted that the Research and Interagency Coordination Group is specifically charged with the duty of analyzing future trends in the Civil Works Program to help establish priorities in the R&D program. This is, of course, a recognition of the lead-time problem in research and helps us anticipate problems rather than succumb to them.

Along with other division chiefs in the Civil Works Directorate and the deputy director of Engineering and Construction, I am a member of the Civil Works Research and Development Committee. BG Edgar chairs the committee, and I serve as its executive secretary. You probably already realize that the committee is the forum for hammering out policy and funding decisions on the Civil Works R&D program for recommendation to the Director.

I expect that this outline of the Office of Policy part of the Civil Works R&D process affecting coastal engineering may leave you somewhat uncertain about the entire process. I understand that Dr. Choromokos' presentation will include an overview that will help you understand the entire R&D process, of which our contribution is only a part. I will now turn to the other three functions we perform that relate to coastal engineering.

POLICY DEVELOPMENT

In the Civil Works Directorate we have established a formal policy development process for identifying, studying, and making recommendations on policy issues that are within the discretion of the Chief of Engineers or the Director of Civil Works to decide. These issues cover a variety of topics, including coastal engineering matters. They may arise from any source but are only put on the agenda, for processing, with the concurrence of the Director. Recent examples that may be of interest to you are a review of cost sharing for disposal of suitable dredged material on beaches and a review of basic beach erosion control authority with respect to improvement versus restoration.

POLICY ANALYSIS AND REVIEW

One element of the Office of Policy has, as its main item of business, the review of feasibility reports and other project documents on proposed or authorized projects. These are submitted to us by other elements in the Office of the Chief of Engineers (OCE) to analyze the relationship of recommendations to existing policy and legislation. A variety of coastal projects appears among them. Another item of business is dissemination of interpretive guidance on policy matters. One Engineer Regulation in this category relates to Federal participation in shore, hurricane, tidal, and lake flood protection.

LEGISLATIVE COORDINATION

The final function I will discuss is legislative coordination. Where changes in legislation affecting the Corps or its civil works program--including general beach erosion control or related coastal legislation--are proposed by the Corps, the Administration, or Congressional interests, we serve as the conduit for working-level OCE-Congressional coordination of the matters. For example, one feature of the Administration's comprehensive set of cost-sharing policies submitted to Congress this session by the Secretary of the Army is to change cost sharing for beach erosion projects. The legislative proposal is to allocate the costs of such projects to standard purposes, such as recreation and flood or storm damage reduction, and have them shared by non-Federal interests at 50 percent and 35 percent, respectively. Costs assigned to benefits to privately owned shores or to prevention of land losses would be borne entirely by non-Federal interests. Handling preparation of testimony, informational requests from Congress, and other inquiries about this and other items, is one of our most substantial activities.

DISCUSSION

PROF. WIEGEL: *I'm now thinking of a board meeting that we had many years ago in the New York area. We visited the beach nourishment project there along that portion of Long Island. We also drove through areas that looked almost like they had been bombed out. One of the things that struck us was that here was a beach nourishment project in an urban area, and one of its main purposes was recreation. Sociologically speaking, however, it was able to get the kids off these streets and into recreation as an alternative. Has this been looked into? It seems to me your policy area is the appropriate place that something like this would be pointed out.*

Again I emphasize that there are many different acts that Congress has passed relative to urban types of funding and so forth. Do you consider this sort of thing? In other words, even though it is recreation it is serving a very fundamental sociological purpose to try to get these pressures off these very poor areas.

MR. DUNCAN: We have considered that, and we will continue to do so. The roadblock that we've experienced to date, in addition to the budgetary problems that the Nation faces right now, is that OMB and the Administration don't look to the water resources program to produce recreation on its own. They acknowledge the opportunity created by the development of water resources projects for recreation, and we're encouraged to take that opportunity. But where it's recreation pure and simple, the answer we get is other Federal agencies that have the responsibility are taking that initiative. That doesn't preclude our going back time after time with just the type of example you've raised. We will continue to do that.

BG EDGAR: Don, I think I might add a thought to that. In addressing various projects that have the recreational benefits you've just described, Bob, and given the Administration's view on the priority of recreation as a project purpose, the philosophy of "case by case" has always been used in presenting a project for review. Even though the philosophy may be that recreation is low priority and we don't have money, if there are compelling reasons, the opportunity is there to put it forward for consideration. That doesn't mean that it would be approved, but it would certainly be considered. The answer may be, "No, we don't have the money"; but then again the answer might be an exception to a certain policy. It's not completely closed out, but the odds are very slim that something that is totally recreation oriented is going to go if its water resources are relegated to the Corps of Engineers.

CERB Proceedings

OVERVIEW OF NATIONAL DREDGING PROGRAM

Mr. William R. Murden, Chief
Dredging Division
Water Resources Support Center

ABSTRACT

The US Army Corps of Engineers has been involved in dredging from its inception. Over the years, dredging technology as well as techniques for disposal of dredged material has undergone numerous changes. Discussed in this report are some of these changes in addition to the shared responsibilities of dredging work.

INTRODUCTION

I am here today to present an overview of the National Dredging Program. One of the earliest and most fundamental missions of the US Army Corps of Engineers (Corps) was the responsibility for navigation maintenance--opening up rivers and keeping them clear of snags and debris so that navigation commerce could progress uninterrupted. This role quickly expanded to include channel improvement as well as a maintenance program requiring dredging. Today, about 40 percent of the Corps' Operations and Management budget is allocated to dredging, specifically navigation-related improvements and maintenance of our 25,000 miles of navigable waterways and over 400 ports.

Dredges and dredging techniques have undergone a technological revolution during the last decade or so. Some of the developments include automated dredging systems, unmanned engine rooms, and automated production equipment. Many of these improvements were the result of large-scale port deepening projects around the world and, to some degree, environmental requirements.

TYPES OF DREDGES

Today there are two basic types of dredging equipment--mechanical and hydraulic. The determination of which type to use depends on the material to be dredged, the site and its accessibility, the disposal method, and the wave and weather conditions.

Mechanical dredges include bucket, grab, dipper, backhoe, and scraper.

They have the advantage of being able to operate near docks, bulkheads, piers, and other structures. The high material-to-water ratio of mechanical dredges is an important factor when hauling dredged material over long distances or placing it into diked containment areas. Grab or clamshell dredges also have the advantage of a relatively unlimited dredging depth. Dipper and bucket dredges are usually most efficient in the removal of compact material such as fine-grained sand, clay, and some forms of rock.

Hydraulic dredges, which include cutterheads, dustpans, sidecasters, and hoppers, use involute centrifugal pumps to remove material from the waterways. The material mixes with water to form a slurry, which is then pumped through a pipeline to a disposal area or, in the case of hopper and sidecaster dredges, unloaded into open water sites. The shearing action of the cutterheads makes them best suited for the removal of large volumes of consolidated material. Dustpan dredges, which were invented by the Corps, remove the large volume of sediments which accumulates each year in the Mississippi River. Hoppers, so-called for their containers which are used to transport material to open water or ocean disposal sites, can operate while a ship is under way and not obstruct navigation. Some hopper dredges are equipped to pump the material from the bins through a pipeline to a disposal area or beach nourishment operation. Sidecasters, another Corps invention, operate in shallow ocean inlets discharging material through a boom which extends off the side of the dredge. The pneumatic dredge is a special-purpose hydraulic dredge which has a relatively low production rate but is extremely useful in dredging polluted material because of its ability to minimize agitation.

SHARED RESPONSIBILITIES OF DREDGING WORK

During the last 20 years or so, the new work or improvement dredging share of the total dredging program declined steadily because of the completion of major navigation projects without the initiation of any new dredging programs such as port deepenings. Another major factor in the drastic decline has been the opposition presented by environmental groups. For example, the Baltimore Harbor deepening was authorized in 1970 and is still not under way. Table 1 shows how the total dredging was distributed between industry and the government during this period by yardage. Table 2 shows how the work was distributed by cost.

TABLE 1

SHARE OF TOTAL CORPS OF ENGINEERS DREDGING PROGRAM BY YARDAGE (cubic yards in percentage)

Year	Contractor Maintenance	Contractor New Work	Government Maintenance	Government New Work
1964	27	43	26	4
1965	31	35	30	5
1966	34	29	32	6
1967	32	24	40	4
1968	39	20	34	7
1969	27	28	41	4
1970	41	19	36	3
1971	37	18	41	4
1972	35	15	46	4
1973	42	9	46	3
1974	40	11	47	2
1975	33	17	47	2
1976	41	14	44	1
1977	43	14	43	0
1978	42	24	33	1
1979	52	16	31	1
1980	55	18	27	0
1981	49	27	24	0
1982	58	20	22	0
1983	72	11	17	0

TABLE 2

SHARE OF TOTAL CORPS OF ENGINEERS
DREDGING PROGRAM BY COST
(dollars in percentage)

Year	Contractor Maintenance	Contractor New Work	Government Maintenance	Government New Work
1964	20	54	21	4
1965	23	49	23	5
1966	26	44	25	6
1967	25	37	33	5
1968	30	31	32	6
1969	27	35	34	4
1970	38	23	34	5
1971	33	30	33	4
1972	35	26	35	4
1973	39	25	32	4
1974	44	16	36	4
1975	34	26	36	3
1976	36	28	35	2
1977	39	24	37	1
1978	40	30	29	1
1979	48	23	27	2
1980	53	24	23	1
1981	52	25	23	0
1982	53	30	17	0
1983	66	20	14	0

In 1964, contractors performed 70 percent of the total dredging work for 74 percent of the total cost (Figure 1). By 1984, the contractors were performing 83 percent of the work for 86 percent of the money. However, please note that there was a steady decline in the contractors' share of the work from 1964 to 1972 (Figure 2), where it held steady at approximately 50 percent until 1976. The increase in the industry's share of work meant that the government share had to be decreased.

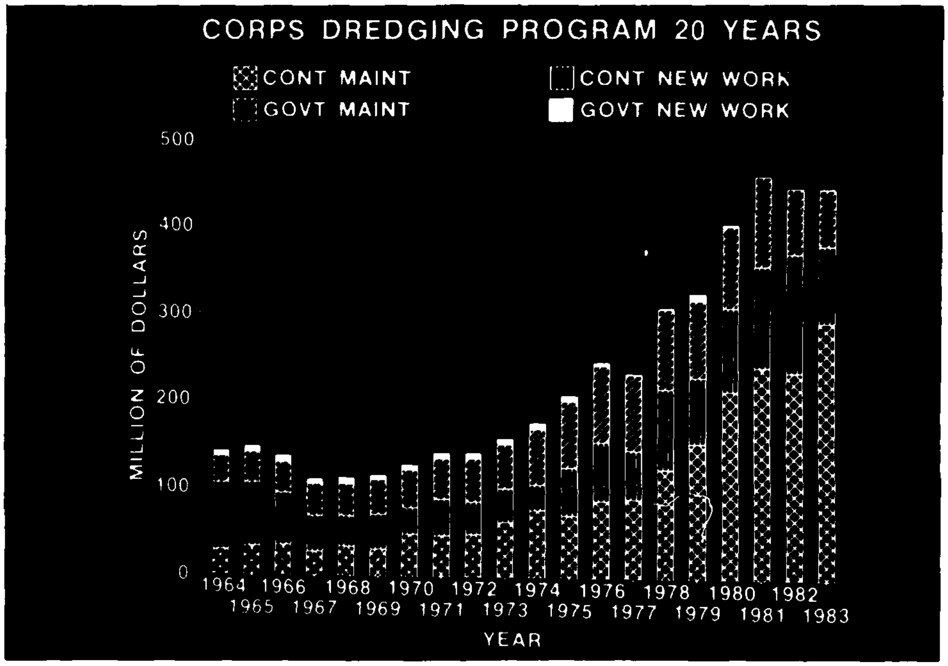

FIGURE 1. COMPARISON OF CORPS AND CONTRACTOR'S SHARE OF DREDGING WORK BY COST

The drastic decline in new work or improvement dredging from 1964 to 1976 placed the dredging industry in difficult financial straits. The dredging industry, therefore, began to actively seek the work previously performed by government owned and operated dredges. The Corps responded by placing industry dredges in direct bidding competition with government hopper dredges. With the passing of PL 95-269 came the Industry Capability Program. Reports from this 5-year program showed that the industry does have the capability of doing the dredging work formerly done by the government.

Figure 3 shows the distribution of the annual dredging work load by type of dredge. To date, the two major classifications, hopper and nonhopper, have been sufficient. As more data become available about the competition between the various types of dredges, a more detailed breakdown will develop.

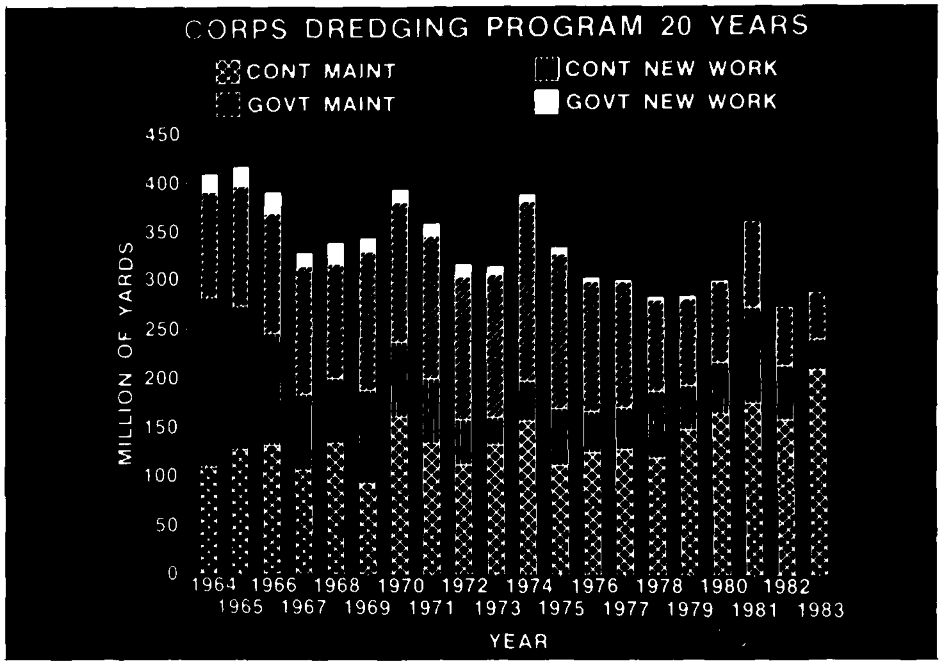

FIGURE 2. COMPARISON OF CORPS AND CONTRACTOR'S SHARE OF DREDGING WORK BY YARDAGE

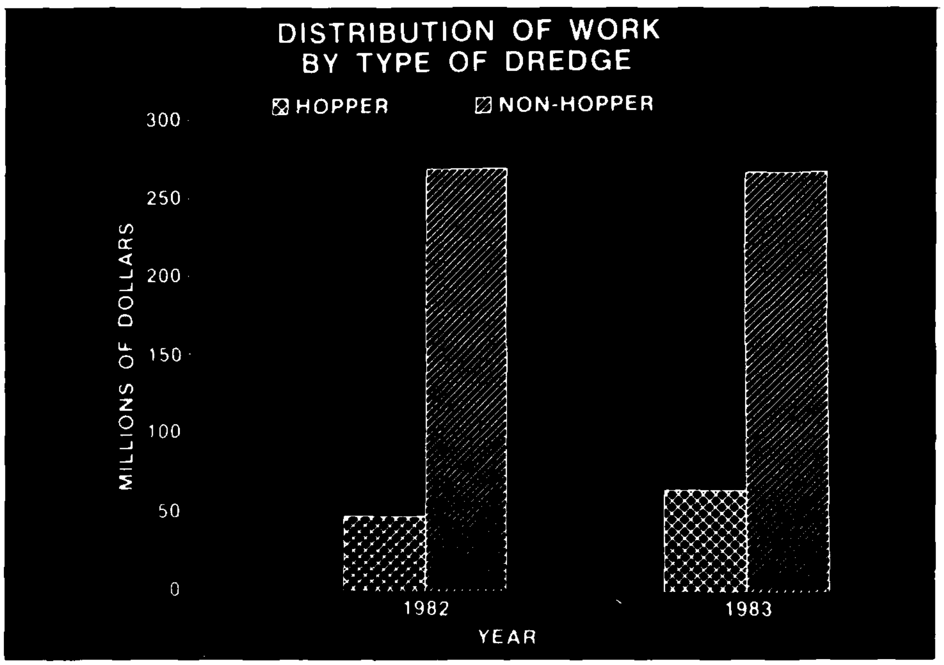

FIGURE 3. DISTRIBUTION OF WORK BY TYPE OF DREDGE

CORPS RESPONSE TO DREDGING NEEDS

PL 95-269 was enacted on 26 April 1978, mandating a gradual reduction in the Federal dredge fleet to the minimum number necessary while still providing for emergency and national defense needs. The private dredging industry was encouraged to build up its hopper dredge capability to make up the difference between the yardage capability at the time of the enactment of PL 95-269 and the yardage capability of the Federally owned minimum fleet.

The Corps of Engineers Reserve Fleet (CERF) program was introduced in 1981 with the understanding that Corps vessels would provide initial response to emergency and defense needs, and only when the requirement exceeded the Corps capabilities would the industry step in. This CERF concept was successfully tested in October 1984 during "Exercise Powder River" in a mobilization mission aimed at restoring full transportation capability to the navigation channels in Mobile Harbor. This was not a "paper exercise." The activation of a CERF industry hopper dredge was under real world conditions, and the industry firm responded within 72 hours reaction time specified in our CERF agreement. Equally important was the fact that the industry dredge performed well, completing its assignment well ahead of schedule.

Since the enactment of PL 95-269, the Corps has retired 25 old and obsolete dredges to achieve the desired minimum fleet level of 10 dredges (4 seagoing hoppers, 3 dustpans, 1 cutterhead, and 2 sidecasters), as established by the Administration. We have almost reached that target. The current status of the Corps Minimum Fleet is 12 dredges--4 hoppers, 3 dustpans, 1 cutterhead, 3 sidecasters, and 1 special purpose dredge. The industry has responded to PL 95-269 by building 12 hopper dredges, with another currently under construction.

REDEFINITION OF DREDGING TERMINOLOGY

For many years, dredged material was called "dredged spoil" or "sewage sludge." The Corps has spent much time and money attempting to correct the misconception that these negative terms are synonymous with dredged material. In 1978, the 5-year Dredged Material Research Program (DMRP) was completed by the Corps at a cost of $33 million. The DMRP and subsequent research showed that most of the material (about 90 percent) dredged in the US is not polluted, when compared to existing stringent criteria for open water disposal. Our job now is to disseminate this information to the public so that the stigma attached to dredging can be removed.

Today, our total expenditure for research and development on the effects of dredged material disposal has reached over $100 million. The bulk of this research is carried out at the Waterways Experiment Station (WES). The primary task of the Dredging Operations Technical Support, located at WES, is to provide Civil Works, Water Resources Support Center (WRSC), and field personnel with timely assistance on any dredging problems.

The Marine Design Center, located in Philadelphia, was established to design and construct the complex marine craft necessary to keep our inland and coastal waterways operable. As the center of expertise for naval architecture, we have concentrated our activities on designing dredges, floating cranes, and towboats for the Corps and making recommendations on environmental problems.

Unfortunately, the prevailing perception is that dredging and disposal are, on balance, environmentally damaging. The Corps' research program has, therefore, focused on minimizing adverse environmental effects and seeking opportunities to balance them with uses of dredged material which are socially and environmentally beneficial.

DISPOSAL AND USES OF DREDGED MATERIAL

The disposal of dredged material is the most difficult problem in the National Dredging Program. Figure 4 shows the three basic options for the disposal of the 465 million cu yd of material that are dredged each year to maintain and improve our navigation system. About 65 million cu yd are disposed of in ocean waters; another 135 million cu yd are disposed of in upland areas; while the remainder goes inland to open waters.

Our research has focused on finding beneficial uses for the disposal sites as well as for the material itself. One of these is beach nourishment, where the dredged material is placed along the coast to replace sand washed away by erosion. Dredged material can also be used to create and rehabilitate marshes which have been lost due to subsidence and erosion. On the South

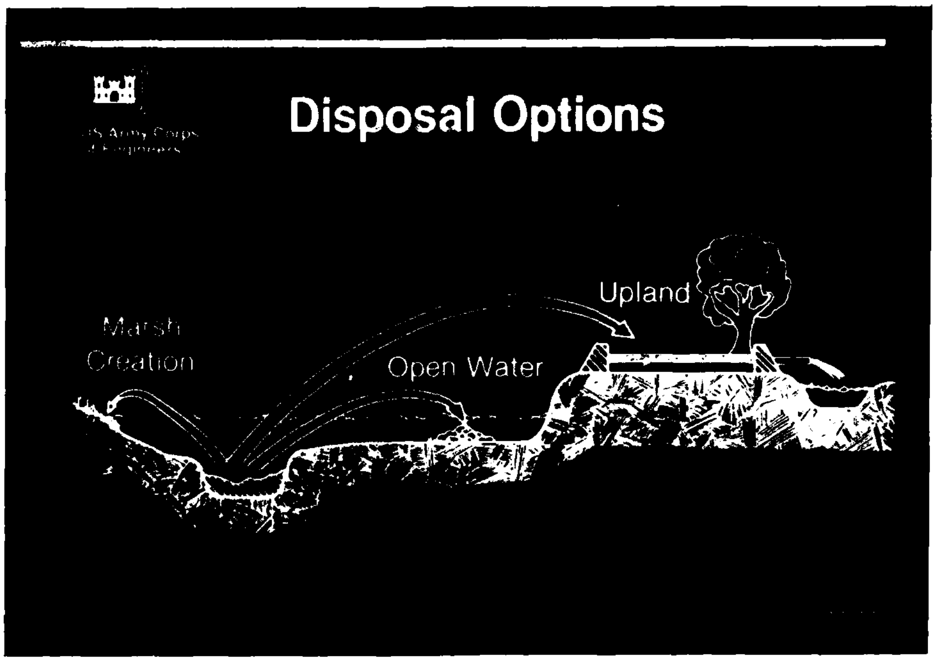

FIGURE 4. OPTIONS FOR DREDGED MATERIAL DISPOSAL

Atlantic and Gulf coasts, the Corps has used dredged material to create a string of islands and set them aside for wildlife. The Corps has had tremendous success in establishing these areas as nesting sites and as stopovers and wintering areas for migratory waterfowl. Much of the material that we dredge as we deepen harbors is coarse-grained sand, which is in demand in some areas for construction aggregates.

Still another use currently being considered is to place the material in the form of an underwater berm to reduce wave energy and create fish habitat. Recently, General Wall arranged for me to brief the leadership of the National Marine Fisheries Service (NMFS) on the concept of an underwater berm. To my surprise and pleasure, the NMFS Headquarters Staff reacted positively and enthusiastically. They have since assigned an NMFS staff member to the Board of Engineers for Rivers and Harbors to work with us in exploring this concept and have asked us to join them in exploring the creation of oyster bars or reefs with dredged material.

CONCLUSION

"Cost sharing" is not new to you; it has been applicable to beach nourishment projects for a long time. However, it will be new in the navigation and dredging areas. When cost sharing becomes a reality, it will bring many new challenges, and I believe that many ports and states will be motivated to evaluate new dredging procedures. Thus, NOW is a good time to think about innovative approaches. Instead of placing dredged material in traditional disposal areas, why not establish zones generally parallel to the shoreline and create underwater berms? (They cannot be any more damaging than the ocean sites we use today, and they might dissipate wave energy and create a habitat conducive to fish.) Other approaches are to:

(1) Evaluate existing ocean disposal areas to determine whether some of the existing sites are located so that the littoral patterns tend to move the material back into the channel.

(2) Assign personnel from the Coastal Engineering Research Center (CERC) to the WRSC to assist in planning the underwater berm concept for offshore and bar entrance channels. (We are off to a good start with the NMFS support, but we can use all the help we can get.)

(3) Investigate what is going on in the Permanent International Association of Navigation Congresses (PIANC) world. From time to time, international working groups are authorized in the technical/professional activities of PIANC. (The Chief is an international vice-president of the organization and a strong supporter of PIANC. The PIANC Secretariat for the United States is a component of the WRSC. We can assist you in becoming a member of one of the working groups, if you contact us.)

(4) Consider assigning studies to the Marine Board of the National Academy of Sciences. (Favorable conclusions from this prestigious organization can go a long way in developing public acceptance of new ideas and approaches.)

I believe that the National Dredging Program would benefit greatly from a joint effort and a closer relationship between the WRSC and the Coastal Engineering Research Board and CERC. When the deepening of our ports begins, and it will soon, we, as a team, should be ready to offer some new and productive ideas which will save money and still be compatible with environmental values.

DISCUSSION

DR. LE MÉHAUTÉ: *Dredging is not my speciality; nevertheless, in one of our past meetings we had expressed concern about the small amount of money going into research on dredging technology, not the effect of dredged material, but dredging technology, as compared, for example, to what was invested by the Dutch. I did not know that you had the Marine Research Center, and maybe that's where it is done. But can you comment, please, on what is being done to improve the efficiency of dredging with cutters and if there is anything being done about it?*

MR. MURDEN: Sir, very briefly, we have had the technology from the standpoint of equipment design and methodology; but there have been limited opportunities for Europoort or Gulf de Fos. Meanwhile, over the years we have been very helpful to friends in the Netherlands, France, and Belgium. And with the coming of Europoort and their quick advancements, they have shared the improvements they've made and have been very willing to share with us. We have what is called, in bureaucratic language, Memorandums of Understanding with the Dutch, with the Japanese, and with the French for the expressed purpose of exchanging technology and improvement in equipment and machinery and techniques. These have been very productive. We hold meetings once a year hosted in the respective nations. We've been given full support by our leadership in Civil Works and by the Chief.

So, in essence, our friends in these countries, which have made tremendous advances, have been totally willing to share their drawings, their production data and, to a large degree, equipment at a much lower price than we could buy it in the United States. So through our Marine Design Center and dredging division, we've been very fortunate that our friends remembered that long ago we helped then in the same area.

I hope that answers your question.

BG ROBERTSON: *Bill, you pointed out the advantage of the offshore berm for dredged material disposal as well as for improvement of fish habitat. It seems that we have a triple headed hammer there also as an energy dissipater for protection of beaches, hurricane protection, and so forth. And I don't know what we're doing in that area—at the Coastal Engineering Research Center in research on offshore berm as an energy dissipater—but I would think that it would be right in our purview to recommend and strongly support such a program. I might ask Dr. Whalin what we're doing in that area. Also, should we as a Board encourage increased effort for the triple hammer advantage that we can get for the Nation?*

DR. WHALIN: *I certainly would say "yes" to your last question, "should we encourage it?" We worked with Bill's people in Norfolk District on a small demonstration project at Virginia Beach, the area Bill mentioned earlier. We've come to a sort of standstill on that particular effort due to the situation with the project in the District, but our people are talking with the Water Resource Service Commission (WRSC) about really pursuing this more aggressively. This was on a reimbursable basis for Norfolk District over the last couple of years.*

We did have a very small demonstration project with some existing material where we monitored the movement of some material in an underwater berm that the District constructed from their existing maintenance dredging. It looks good. We're just as enthusiastic about it as Bill is, and I guess the only thing probably holding us back a little bit is money, really. Do we reprioritize money within our own program? I think we probably need to go to some office studies and to some full-scale demonstrations. I don't know—we're in the talking stage on this. Bill may want to comment.

MR. MURDEN: Yes, sir, if I could. General Robertson, we're strictly in the planning stage, and there have been those in the Corps and without who were not supported about a year ago. But having the National Marine Fisheries Service (NMFS) leadership being enthusiastic and very positive in their reactions and looking for a demonstration site where your current operations would be is like going to the demonstration approach where you could save Thimble Shoal a million dollars. You could then devote that saving or cost avoidance to the baseline data collection, the monitoring, and the evaluation. So our next thought is to get with Bob Whalin and his folks and pick that site where you could save a million bucks roughly and apply that toward baseline data collection without having to reach out for a million dollars or something from the blue sky or from my good friend Cecil Goad, because I'm always asking for money from him.

But we are moving ahead, and I wanted the Board to be aware of what I think is a great opportunity, not only for the idea of offshore beaches but also for the disposal areas. It might take a long time to build that berm properly, but at least you'd be heading in the right direction.

PROF. WIEGEL: Back in the late 1930's the Corps of Engineers did exactly this for another reason. One was in Santa Barbara, California; the other, I believe, was off Long Branch, New Jersey. I'm not certain that was New Jersey.

MR. MURDEN: That's exactly right. It was Long Branch, and Jay Hall was the one who mentioned that 50 years ago.

PROF. WIEGEL: Yes. The idea of dredging was to put the material in the littoral region rather than trying to move it onto the shore because of getting it cheaper. I requested a study to find out what had happened to those offshore bars, and I guess it was Jay Hall who made a report about their standing for many years.

MR. MURDEN: Sir, I think they're still there, and one of the things I'm going to ask Dr. Whalin and COL Lee to do is to work with us to run some sort of reconnaissance evaluation as to how much of those mounds still exist. That might be another point on the curve.

DR. NUMMEDAL: My problem is related to what has been discussed. There are a number of natural sand ridges in slightly deeper water than the fisher longshore bars all along in New Jersey, Long Island, and some of our shore faces. It might be worthwhile to look at the characteristics of some of these to determine which ones are stable, how big they have to be in order to be stable, and what they do to the currents or the waves on the beach behind. I think you'll find a number of very good examples along the New Jersey coastline.

MR. MURDEN: Sir, I agree with you thoroughly. As a matter of fact, Mr. Homer, who works for our Board of Engineers of Rivers and Harbors recently, made the same suggestion, and we will follow up on that.

COASTAL ENGINEERING RESPONSIBILITIES OF THE RESEARCH AND DEVELOPMENT DIRECTORATE

CERB Proceedings

Dr. William E. Roper, Assistant Director
Directorate of Research and Development
Office, Chief of Engineers

ABSTRACT

Coastal Engineering Research is an applied program addressing the identified needs of the Civil Works Program. It is managed by the Research and Development (R&D) Directorate and is closely coordinated with the Civil Works and Engineering and Construction Directorates through a network of technical monitors. During program development all elements of the Corps of Engineers have the opportunity to participate in research prioritization. Management of Coastal Research execution includes semiannual line-item reviews, financial performance analysis, technical monitor coordination, field working group reviews, and annual detailed program reviews. Program direction is for 70 percent in-house and 30 percent contracted-out effort. Reimbursable projects must be applicable to coastal R&D missions, require no additional laboratory personnel resources, and not compete with the private sector. There is an emphasis on technology transfer and user application of coastal R&D products.

INTRODUCTION

The Research and Development (R&D) Directorate has responsibility for development, defense, and execution of the Corps' Coastal Engineering Research and Development program. Coastal engineering is the second largest Civil Works Research Area with over $6 million of a total $34 million direct funded research program in fiscal year 1985 (FY 85) (Table 1). In addition, a comparable amount of reimbursable support to Corps districts and divisions and other Federal and state agencies is conducted at our laboratories in the Coastal Engineering Area.

PROGRAM MANAGEMENT

Program Review

The development of the coastal engineering program is a coordinated effort among R&D, Civil Works, and the Engineering and Construction Directorates, as shown in Figure 1. It begins each year with the identification of research needs by field users, laboratories, and technical monitors at the

TABLE 1
CIVIL WORKS R&D PROGRAM
(dollars in millions)

Research Area		FY 84	FY 85	FY 86	FY 87	FY 85
Materials	$ 2,850	$ 2,420	$ 2,720	$ 2,830	$ 2,830	
Coastal Engineering		6,583	6,075	6,275	6,050	6,050
Flood Control and Navigation	2,720	2,680	2,880	3,080	3,080	
Environmental Quality		2,695	2,470	2,570	2,620	2,620
Water Resources Planning		2,260	2,550	2,720	2,260	2,200
Surveying and Satellite		1,120	1,150	1,255	1,255	1,255
Construction, Operation, and Maintenance		10,570	15,785	17,460	15,985	$13,080
CERB	200	220	230	240	250	
Technology Transfer		235	220			
Total		$29,233	$33,570	$36,100	$34,320	$31,365

Office of the Chief of Engineers (OCE). These needs are reviewed and prioritized by the technical monitors and submitted by the Civil Works Policy Office to the R&D Directorate for implementation. A proposed R&D program is then developed by the laboratories through the R&D Directorate to respond to these prioritized needs. Detailed program reviews in each of the 32 research

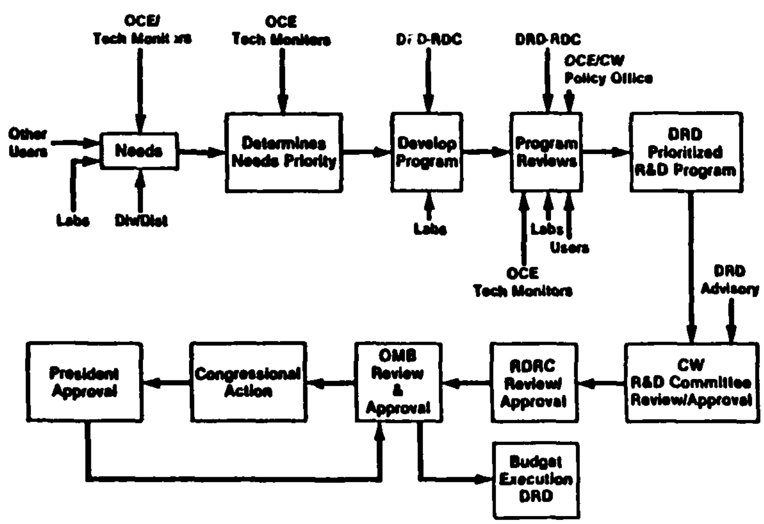

FIGURE 1. CIVIL WORKS R&D PROGRAM CYCLE

programs are conducted by the R&D Directorate in the February to May time frame involving participation by the labs, OCE, and the field.

Needs Prioritization

Based on the results of these reviews, the R&D Directorate develops a prioritized proposed R&D program for the next fiscal year. This program is submitted to the Civil Works R&D Committee for review and approval and forwarded to the Assistant Secretary of the Army for Civil Works as part of the overall Civil Works budget. The R&D program is also briefed to the Corps R&D Review Committee which is chaired by the Deputy Chief of Engineers. However, the Civil Works R&D Committee is the major budget decision-making element in the program development cycle. For the past several years a special briefing has been presented to the committee on the proposed coastal engineering program in preparation for a budget decision-making session. The Deputy Director of Civil Works is the chairman of the Civil Works R&D Committee, with the R&D Directorate as a non-voting advisory member and the Civil Works Policy Office as the executive secretary.

The technical monitors are a key element in the Corps' Civil Works R&D Program. In addition to their role in R&D needs prioritization and program review, they provide continuing technical guidance on project performance and facilitate top management participation and support of R&D within their directorates.

Coordination with Civil Works

The R&D Directorate also works closely with the Civil Works program and the field in identifying requirements and opportunities for field demonstration programs in specific technology areas. Examples of such programs are the completed floating breakwater prototype study, the ongoing field verification program, and the dolos prototype test. In these cases an R&D effort was "piggy backed" into an existing civil works project to expand the results of study and make the lessons learned available throughout the Corps.

BUDGET DOCUMENTATION AND FUNDS ALLOCATION

The R&D Directorate is responsible for defending the proposed R&D program both within OCE and to the Office of Management and Budget (OMB) and the Congress. Budget documentation is prepared and submitted as part of the overall Civil Works budget package. R&D represents the program at OMB hearings and provides testimony at congressional hearings.

The R&D Directorate manages the execution of the Coastal Engineering Research Program within the Corps. This includes allocation and tracking of funds to assure proper program execution and project performance. Every six months a detailed line-item review of the total Coastal Engineering Research Program is conducted to provide policy guidance and assess timeliness and quality of work. In execution of the program one area of emphasis is the proper balance between in-house and contracted efforts. We have established a goal of 30 percent contract-out work for coastal engineering as well as for the other research areas. Emphasis has been placed on technology transfer both between the military and civil R&D programs and to the private sector under the Stevenson Wydler Act.

A second area of concern is the balance between basic and applied research in the program. Current trends have been to increase applied research at the expense of more basic programs. This is primarily due to limitations on General Investigations (GI) funding which has a history of level or decreased funding over the past 5 years. The erosion of new technology development capability is being addressed with recommended support for additional funding in the direct allotted coastal engineering program. Incidentally, the problem of diminished research support in the direct funded programs applies across the board in Civil Works R&D.

Reimbursable projects are also monitored and reviewed by the R&D Directorate. Reimbursable projects over $50,000 must have Headquarters approval. The approval criteria are: (1) applicability to the Civil Works R&D Program; (2) no requirement for additional personnel resources; and (3) no competition for work with the private sector. The reimbursable program is an important part of the overall coastal engineering R&D work. Because it is closely related to direct funded R&D, it often provides the additional resources that are currently unavailable through the direct funded program to conduct research that is specific to a particular project but can be extrapolated to broader application.

SUMMARY

The Coastal Engineering R&D Program is guided by the following six general policies. It must:

(1) Be mission oriented to support civil works.

(2) Have close user interaction with field and OCE.

(3) Exploit new technology to benefit Corps mission.

(4) Emphasize user application and technology transfer.

(5) Maintain/enhance Corps technical credibility through high quality, useful R&D.

(6) Maximize benefit to Corps from mission support programs.

The program is mission oriented to support Civil Works. The R&D Directorate through the laboratories provides a technical support service to the Districts, Divisions, and OCE. There is a close user interaction with the field, OCE, and the R&D community. We have fostered that relationship in a number of ways, including the establishment of field review groups on major research programs; and we feel it is important in keeping the research program tuned to the needs of the Civil Works Program. The majority of our activities consists of adapting or exploiting new technology to benefit Corps missions.

We do not do a great deal of new technology development. Emphasis is on user application and technology transfer both within the Corps and to the private sector. In this area there is a tremendous synergism between our military and civil works research programs. Through our management and policy framework our goal is to maintain and enhance the Corps' technical credibility through high quality usable research. Finally, our mission support activities which are the largest dollar part of our total R&D program are selected and carried out to maximize the benefit to the Corps as well as to the customer.

DISCUSSION

DR. LE MÉHAUTÉ: I do not have any questions, but I just want to say that your concern about the lack of basic research is well received, and I'm very glad to hear what you had to say about it.

PROF. WIEGEL: Yes, civil engineering is, I think, in very bad shape. I've met with different people in NSF in the last few months, and the feeling I get is we do not have the money in civil engineering. The new centers that they're setting up are just about as far removed from civil engineering problems as you can get. Now we have no idea what the next ones are going to be, but the trickle down information you get is that civil isn't going to do very well. So I don't know who's going to be doing this research that's not directly mission oriented.

In the State of California, with our new governor, the education budgets are recovering, but there's no recovery whatsoever in any of the money that goes into engineering research and things of that sort. So, I guess we can get into this when we get into the overall discussion, but I think it's a real serious problem here.

COASTAL ENGINEERING RESPONSIBILITIES OF THE PLANNING DIVISION

Dr. Lewis H. Blakey, Chief
Planning Division
Directorate of Civil Works
Office, Chief of Engineers

ABSTRACT

The Planning Division is responsible for all preconstruction planning for the civil works mission of the Corps. We provide guidance to the Field Operating Activities, and we track, review, and evaluate those complex, multifaceted water resource studies leading to authorization. The uncertainties of many coastal studies demand particular attention and require intensive research and coordination.

INTRODUCTION

Since this is the lead-off presentation of the various elements of the Office of the Chief of Engineers (OCE), let me first say that I define the word "engineering" in the title of this Board in the broadest possible terms. Planning is one facet of the continuum of engineering activities that range from planning, to design, to construction, to operation and maintenance (to put it in terms familiar to all Corps of Engineers (Corps) people). Our involvement with the activities of the Board (and all coastal matters) is thus, by definition, up front.

The coastal elements with which we regularly deal in the Planning Division include (but are not limited to) the review of Corps coastal studies from a policy perspective and a number of special assignments, such as management of low cost shore protection (Section 54 Program), oversight of coastal zone management, sea level rise, barrier islands, and coastal engineering Research and Development (R&D). Two studies that are of special interest are the Coast of California Storm and Tidal Wave Study and the Coast of Florida Erosion and Storm Effects Study. These special planning-oriented studies will not recommend projects; rather, they will generate and archive the basic data for future site-specific studies. These studies are prototypes of what may be a series which could cover all of the coasts. In conjunction with appropriate models, remote sensing techniques, and a comprehensive data base, these studies can decrease the time and cost of studies in the future.

THE VALUE OF RESEARCH AND DEVELOPMENT TO PLANNERS

I have recently corresponded with all the planning chiefs in the Division offices concerning the value of R&D to planners. You will be interested to hear that a number of the planning chiefs are acutely aware of the value of coastal research in the accomplishment of their programs. They further recognize that even though the research primarily addresses design factors, the information developed is of significant importance to planners. To assist in the focusing of research of these problems as perceived by planners, one of the two technical monitors for coastal engineering R&D is in the Planning Division. It is very important that the technology transfer of coastal engineering research take place so that our field planners can utilize the latest thinking in formulating a plan.

So that no misconception exists, you should understand that planners are not more interested in the economic and environmental factors than in the hard "engineering" factors. Rather, with the very limited funds available for planning studies, a number of trade-offs must be made, and usually detailed study of many engineering factors is deferred until after a project has been authorized. An illustration of this can be seen in the area of modeling. As you know, much of the functional design of coastal projects is accomplished during the planning phase. Many times when it appears that models (both physical and numerical) are appropriate to proper planning, we opt to defer that modeling until after a project is authorized. In those cases where we do not reformulate our plans, we preclude those options requiring models for analysis. In other words, we do the functional design without the aid of models. We should be looking at a broad spectrum of options in the planning process, and that means having enough hard data from modeling to rationally plan.

In the OCE Planning Division, our coastal expertise is primarily in the Flood Plain Management Services (FPMS) and Coastal Resources Branch, and a primary concern is that the field planners have access to the best information available. We have concentrated our efforts to ensure that planners' needs are carefully considered when prioritizing coastal research. One area where our FPMS program complements our coastal resources efforts is the hurricane evacuation studies conducted jointly with the Federal Emergency Management Agency and the National Oceanic and Atmospheric Administration. Continued research in support of this effort is needed. Past tsunami research has resulted in successfully completing FPMS tsunami frequency and run-up studies.

Shore Protection

You are all aware that a favored method of shore protection (especially when recreation benefits are derived) is periodic nourishment. There is still much to be understood about the process but even more to be accomplished by getting the ideas accepted by the public which often perceives the process as "throwing good money after bad." Although some have a good understanding, the more vocal public segment is highly critical. They have beaten the drums loudly for abandoning the coast to "mother nature" with the story that anything that man does at the coastline increases erosion. We don't believe it, and so we continue our research to set the record straight with facts.

Section 54 Program

You have had briefings on the Section 54 Program at previous Board meetings, so I'll only mention a few items. First, the dissemination phase is still going strong. Second, the Chief, General Heiberg, is now exploring an initiative to continue looking at low cost devices. Where we will go with this is uncertain at this time.

Coastal Zone Management

Coastal zone management is an area where much coordination has taken place with NOAA of the Department of Commerce. The most serious problem for the Corps involves the consistency provisions of the Coastal Zone Management (CZM) Act--that Corps activities must (to the maximum extent practicable) not be inconsistent with an approved (by the Secretary of Commerce) CZM plan. Many state plans are written in broad, vague language, and it is often difficult for the planner in the field to know exactly where the limits are; thus, a continuing close coordination with the states is required.

Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA, pronounced Cobra) mandates that no Federal funds are to be expended on "undeveloped barrier islands." The islands so classified are those demarked by lines that Congress has drawn on maps, without any other citation or specification. Some of the islands we would not classify as undeveloped, but Congress has spoken (or rather drawn). The rationale for CBRA is twofold: first, to maintain the islands' environmental quality by limiting future development by withholding any Federal subsidization of new works on those islands (bridges, roads, sewerage, shore protection, etc.); and second, to reduce the drain on the Federal treasury.

There are a number of exceptions of interest to the Corps, including maintenance of existing navigation channels and new shore protection works using either sand placement or vegetation. Other than these, no new work can be accomplished by the Corps. CBRA, however, does not restrict the expenditure of non-Federal funds; and private developers can build to their unsubsidized hearts' content, but the lack of Federal flood insurance is a real deterrent. We are in the process of reviewing a Department of Interior proposed extension to the Coastal Barrier Resources System (the islands per se) which would include islands in every coastal state except Illinois. We won't know the impact until some time next month.

Sea Level Rise

Sea level rise is a topic that made big headlines when the Environmental Protection Agency (EPA) put out its report last year. Their projections were and are quite controversial. A National Academy of Sciences study has come up with a different magnitude of sea level rise. This suggests that there are a lot of different assumptions and processes that should also be considered. We know that research is under way and that much more needs to be done. However, our guidance to the Field Operating Activities at this time is to rationally consider relative sea level rise in the planning process where the tide data in the region suggest it is important and to make their formulations accordingly. We are tracking the Marine Board's deliberations, and we will incorporate additional guidance based on the outcome of their studies.

CURRENT EFFORTS

We have at the Washington level a total of 206 reports recommending Federal action. Of these, 89 reports involve projects in the coastal regions, which is nearly half of the total Corps' work. The total dollar value of these projects is $13.1 billion, of which coastal is $4.4 billion. The coastal regions of this country constitute the frontier, as far as new methodologies and new and innovative planning techniques are concerned. As indicated, the Corps' planned workload, translated into real coastal development, is big. We have accomplished much; however, there is even more to do requiring tools which at present do not exist to address coastal problems yet to be identified. Thus, the far-reaching impact of what coastal research we now do and plan has an added significance.

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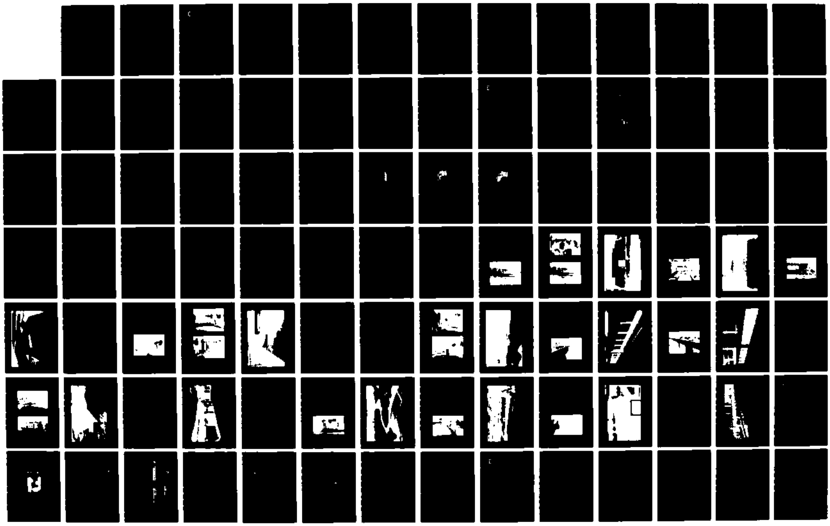

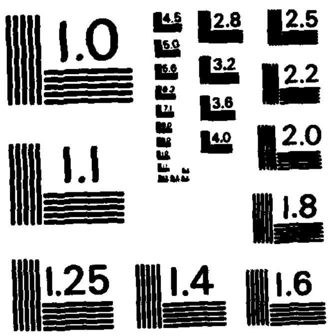
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It is often difficult to predict the problems that our field planners will be facing 5 years hence, but that is the lead time needed to influence what research is initiated today. We are trying to analyze (through a crystal ball clouded by political considerations) the future Corps missions. We are certain, however, that the coastal resources problems, with all their uncertainties, complications, and complexities, will continue to require our attention and demand that our coastal planners become even more innovative as the Federal budget declines. The stakes are high, but the payoff is extraordinary. The challenges of coastal work can only increase; the easy problems have been solved. So let's get at the hard ones.

CERB

Proceedings

RESPONSIBILITIES OF THE COASTAL ENGINEERING RESEARCH CENTER FOR COASTAL ENGINEERING: PAST, PRESENT, AND FUTURE

Dr. Robert W. Whalin, Chief
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The Coastal Engineering Research Center's primary responsibilities for coastal engineering include conduct of the Corps' coastal engineering Research and Development program, execution of the Coastal Field Data Collection program, management of Monitoring Completed Coastal Projects, operation of a Coastal Engineering Information Analysis Center, technical review of coastal project reports for the Board of Engineers for Rivers and Harbors, conduct of mission support work for Corps of Engineers field offices, and consultant services in coastal engineering as requested.

Over 50 years ago, the need for carrying out research in the area of coastal engineering was recognized. This need led to the inclusion of provisions in Section 2 of Public Law 71-520, 3 July 1930, which are stated, in part, as follows:

> The Chief of Engineers of the United States Army ... is authorized and directed to cause investigations and studies to be made ... with a view of devising effective means of preventing erosion of the shores of coastal and lake waters by waves and currents .... Provided further, ... that there shall be organized under the Chief of Engineers, United States Army, ... a board of seven members, of whom four shall be officers of the Corps of Engineers and three shall be selected with regard to their special fitness by the Chief of Engineers from among the State agencies cooperating with the War Department. The Board will furnish such technical assistance as may be directed by the Chief of Engineers in the conduct of such studies as may be undertaken and will review the reports of the investigations made.

This Board, the Beach Erosion Board (BEB), officially came into existence on 18 September 1930 under Special Order No. 72, Office of the Chief of Engineers, and initially established a small laboratory at Fort Belvoir, Virginia. The first civilian engineer employed by the Board, Mr. Jay V. Hall, was hired in January 1931. The BEB's first wave tank was constructed for approximately $1,500.

Coastal engineering was a unique specialty in civil engineering, unlike the established disciplines of structural, geotechnical, and hydraulic engineering. Prior to the establishment of the BEB, little research had been done in the United States on coastal engineering, and there were no established university programs directed exclusively toward this particular area of engineering. Research in coastal engineering grew slowly during the 1930's. Public Law 74-409, Section 5, 30 August 1935, required inlet studies to consider shoreline erosion and/or accretion. However, through June 1937, the BEB had received a total of only $160,900.21 and had no direct appropriation for research.

The advent of World War II saw the mobilization of the BEB staff and facilities to support military missions. Civil works activities were suspended at that time. Universities were also called upon by the government to perform needed studies, particularly studies of surf to provide needed information in support of amphibious operations. Such studies were carried out at the University of California, Berkeley, both during and after World War II, and Robert Wiegel and Willard Bascom worked on projects there early in their careers.

After World War II, the BEB slowly evolved as a major funding agency for coastal engineering studies in the United States. Public Law 79-166, 31 July 1945, stated, "... it shall be the duty of the Chief of Engineers, through the Beach Erosion Board, to make general investigations with a view to preventing erosion of the shores of the United States by waves and currents and determining the most suitable methods for the protection, restoration, and development of beaches ...." In 1937 work had started on construction of a wave tank on property at the Dalecarlia Reservation in Washington, DC. The BEB staff moved to this site in 1940, but World War II had temporarily halted civil works activities. With the end of the war and the passage of Public Law 79-166, BEB moved forward on Civil Works research and development (R&D). A large concrete wave tank was constructed at the Dalecarlia site during 1949 and 1950, but final procurement of equipment was delayed by the Korean War, and the wave tank was not into full operation until 1955. A shore processes test basin was also constructed during this period. Following World War II, BEB also operated a field station in California for several years for taking measurements through surf, had field groups for short periods at other coastal points, and funded additional studies at universities. The coastal research program undertaken by BEB had a scope and magnitude that greatly exceeded any previous coastal research program undertaken anywhere in the United States prior to that time. The first direct appropriation received by BEB for research was for $350,000 in 1950.

The first formal contracts let to universities for coastal research were in 1948. The first contractors were the University of California, Berkeley, The Scripps Institution of Oceanography, and New York University.

The BEB also began to sponsor work at that time with the US Army Engineer Waterways Experiment Station (WES). One early collaborative effort between BEB and WES was a model study of uncontrolled tidal inlets on adjacent beaches. On 11 December 1946, BEB adopted a logo which has evolved into the present logo of the Coastal Engineering Research Center (CERC).

During the 1950's, military intelligence continued to be a part of BEB's mission. In 1951, the Military Intelligence Division had a staff of 30 civilians and 12 military personnel. Its budget came from military funds separate from Civil Works appropriations. Changes in the nature of this division's functions and changes in Army organization resulted in the division's being transferred to a different Army agency in 1962. One other major change in BEB's functions occurred in July 1946 when the responsibility for preparation of reports on beach erosion studies was transferred from the BEB staff to the Corps' District Offices.

In October 1948, BEB staff members started preparation of the first edition of Technical Report No. 4, "Shore Protection Planning and Design," which has evolved into CERC's <u>Shore Protection Manual</u>. In 1950, BEB staff members presented papers at the First Conference on Coastal Engineering in Long Beach, California; and in 1953 BEB's first contribution to the Permanent International Association of Navigation Congresses was presented at the meeting held in Rome, Italy.

The severe hurricanes which struck the coastlines of the United States in 1954 caused Congress to enact Public Law 84-71, 15 June 1955, which directed the Corps to carry out hurricane protection studies. The Office of the Chief of Engineers set up a Hurricane Study Coordinating Committee to organize and coordinate a study program, and BEB was assigned that part of the program which involved wave and storm surge determinations.

An innovative shore protection technique which developed to an operational status following World War II was sand bypassing. First tried unsuccessfully at Santa Barbara in 1935, studies by BEB corrected the placement of the bypassed sand and stabilized the downdrift shoreline. Continued improvements have been made in sand bypassing, and CERC is currently preparing an Engineer Manual on the selection of sand bypassing systems.

In the late 1940s and early 1950s, initial consideration was given to consolidating the Board of Engineers for Rivers and Harbors (BERH) with BEB, and BEB with WES. A decision was made at that time to maintain the three organizations as separate functions due to differences in their missions. That decision was partially reversed some 30 years later when CERC was relocated to become a fifth laboratory at WES.

Public Law 88-172, 7 November 1963, abolished BEB. The laboratory and staff of BEB became CERC. CERC was vested with all of the previous research functions of BEB, and a new advisory Board, the Coastal Engineering Research Board (CERB), was established. By the time this transition occurred, BEB, and thus CERC, was largely a Civil Works R&D laboratory, although some military work continued on a reimbursable basis. During the 1960's and 1970's, the annual direct appropriation for Civil Works R&D at CERC had grown to several million dollars. Having finally been given the resources to carry out the mission prescribed by Public Law 71-520 in 1930, CERC carried out major laboratory and field studies and provided a major source of funds for university research on coastal engineering.

In 1973, CERC was relocated to Fort Belvoir, Virginia, because of the necessity of moving from the Dalecarlia site. Considerations of relocating to WES were again set aside at that time. Coincident with the move to Fort Belvoir, a leveling out of funding of R&D programs and higher costs due to the relocation and inflation led to a decline in funding for university R&D. This was coupled with a decision by the Office of Naval Research in the early 1970's to emphasize ocean research rather than coastal. In the early 1980's, coastal engineering funds in the Sea Grant Program were decreased. Research programs of the National Science Foundation (NSF) also had funding constraints in the 1970's and 1980's.

The late 1970's saw a general decline in university programs in coastal engineering. Universities which had ventured into coastal research when funding was readily available moved their emphasis to other research areas, and many coastal programs withered. It would be difficult to identify coastal engineering research today at Stanford University, Colorado State University, and many other universities which had, at one time, carried out such research. While some university programs in coastal engineering have managed to survive at the University of Florida, the University of California at Berkeley, Scripps, and elsewhere, others have switched emphasis to ocean engineering in support of the offshore oil industry, the US Navy, or other agencies involved in ocean engineering.

The 1980's saw a general decline in funding for coastal engineering R&D programs within the Corps. Coupled with inflation, the reductions in funding have reduced the effective R&D funding level to about 50 percent of the FY 80 level. In 1983, CERC was finally transferred to WES as initially proposed some 30 years earlier. The transfer to WES, and the reduced R&D funding levels, prompted a renewed emphasis on support work.

At the time of CERC's relocation, two projects of particular interest were developing. CERC is now actively involved as a technical advisor to the Coast of California study and the Coast of Florida study which is in its initial stages. These studies conform to one of the original intentions of Public Law 71-520 of 1930, "... to cause investigations and studies to be made in cooperat`on with the appropriate agencies of various states on the Atlantic, Pacific, and Gulf coasts and on the Great Lakes, and the Territories...." Thus, through various fluctuations in program support, CERC has been able to partially maintain its original intended mission but lacks sufficient R&D funding support "to cause investigations and studies to be made" to the full extent intended by past legislation. The major portion of the laboratory's budget is from support work for specific applications defined by others.

Additional R&D funding is needed for CERC to renew the Corps' initiative in funding university R&D in coastal engineering and to meet the intentions of past legislation by initiating major coastal studies. Coastal engineering is basically an interdisciplinary field which has, since its inception, involved engineers, geologists, oceanographers, statisticians, and applied mathematicians. At present, no Government agency or other organization acts as a major proponent for coastal research.

In 1984, an ad hoc committee for the Civil and Environmental Engineering Division of the NSF prepared recommendations on the research needs in coastal and ocean engineering. This ad hoc committee clearly demonstrated major continuing needs for research studies in coastal engineering to reduce hazards to life and property, to reduce maintenance of coastal harbors and navigation channels, and to minimize environmental effects on coastal and nearshore construction. This report reads, in part:

> Within the last 20 years, coastal and ocean engineering in the United States has steadily declined from a position of eminence in the world. The decline is a direct result of severely reduced funding of university research in this field. There is a feeling of alarm in this committee that the failure of the Federal Government to fund research, to support graduate students, and to modernize our laboratories has forced United States industries to import technology from the United Kingdom, The Netherlands, Japan, and Norway. The result, if this trend is not reversed, will be a continuing weakening of our present position and a worsening of our balance of payment deficits.

The report further states that "a distinguishing feature of coastal and ocean engineering is that there is less fundamental information from which to design than in terrestrial engineering. This dearth of information can be attributed to three factors: (1) the discipline is young; (2) marine structures require innovation; and (3) it takes time and money to develop proper hazard assessments."

The following efforts were recommended by the ad hoc committee as the activities most needed at this time:

(1) Field Studies

- (a) Hazard assessment.
- (b) Long-term studies.
- (c) Post-event surveys.
- (d) Prototype measurements.
- (e) Tide and long-term sea level rise measurements.

(2) Laboratory Studies

- (a) Upgrade US laboratory capabilities to be at least commensurate with those of foreign laboratories.
- (b) Upgrade antiquated equipment.
- (c) Continue research on resistance characteristics of construction materials and configurations.
- (d) Improve ability to eliminate or reduce harbor siltation.

(3) Analytical Studies

- (a) Advance our ability to predict analytically.

(b) Study statistics (probabilities) of combined effects of extreme events.

(4) Social and Economic Studies--Consider social costs along with monetary costs in designing coastal projects to provide effective land-use planning.

(5) Coastal and Ocean Engineering Graduate Programs -- Provide continuing education for practicing engineers.

Finally, the NSF Committee concludes and recommends that

> Each year in the United States, natural and man-made hazards in our coastal and ocean environs cost many lives and sometimes billions of dollars in loss of property and commerce. These losses can be reduced through engineering research which produces better understanding of the hazards and better ways of dealing with the physical and economic results of severe events. This research carries national importance and should be accomplished within the aegis of a national agency that is relatively free of regulatory pressures and lobbies.

It is obvious that in many ways coastal engineering is as much an art as a science. We need to obtain a better understanding of the physics of coastal processes. Present coastal research is shortsighted in that it is aimed at solving site-specific problems (i.e. fire fighting), and there is no basis for real innovation. We spend vast sums of money on construction, operation, and maintenance; but we will never obtain long-term savings without basic long-term R&D. For the sake of comparison, if you look just at the engineering fields represented by other labs at WES (Structures, Geotechnical, Hydraulics, and Environmental), you will find numerous labs (private, university, and government) doing basic research. For example, the Environmental Protection Agency acts as a proponent for supporting and funding basic environmental research. Such is not the case in coastal engineering. If coastal engineering is to advance, the Corps must assume a leadership role. We must take a good look at questions like the following:

(1) Should the Corps fund more basic coastal engineering R&D to enhance development of innovative ideas to solve long-term Corps problems?

(2) Should the Corps establish a national Center of Excellence in coastal/ocean engineering? If so, what would be required in terms of additional facilities and/or resources?

(3) Should the Corps update the National Shoreline Study?

(4) Should the Corps be the Federal Engineer for coastal/ocean engineering?

(5) Long-term and repetitive Corps projects such as dredging and beach restoration have very large long-term costs. Should the Corps spend additional R&D funds for studies and demonstration projects which, if successful, would result in significant reductions in long-term Corps operating expenses?

(6) Should CERC facilities be expanded to serve as a national laboratory for basic coastal engineering R&D? Who should fund the facilities and their use?

(7) What areas presently in the Coastal R&D Program should receive greater emphasis?

(8) What areas not covered in the present Coastal Program should receive attention?

(9) Can Corps equipment (such as the Coastal Research Amphibious Buggy (CRAB) and facilities (such as the Field Research Facility) be better utilized and/or expanded to be of greater benefit to the Corps and the Nation?

(10) Should the Corps, NSF, universities, etc., pool resources to increase the effectiveness of the limited research dollar?

DISCUSSION AND PLAN OF ACTION

BG EDGAR: Before we address the questions you raised, Robert, I think there were some other questions that came to mind from Board Members and the other presenters.

BG ROBERTSON: Bob, one point you mentioned is that when you moved down here your ratio of engineers and scientists--overall personnel--increased quite a bit. Did you get an efficiency in getting better administrative support and in being in an overall larger laboratory atmosphere? Is that the reason for it?

DR. WHALIN: It's fairly complicated. It's a combination of things. We actually have 17 fewer people employed in the Corps of Engineers due to the relocation. The R&D community has an additional savings of 25 people. These are the people that are in the Humphrey's Engineering Support Agency, such as the travel and the contract folks and so on that remained at Fort Belvoir to support other offices (FESA, WRSC, etc.) at Fort Belvoir. This did not include R&D personnel though. The Corps didn't lose those 25 people, but the R&D Directorate did; so we're not paying for them anymore from R&D funds.

BG ROBERTSON: But you didn't lose that capability; you just picked it up here from WES.

DR. WHALIN; That's right. When we relocated down here, we didn't need all of that. You know, we had an ADP Center at CERC, and we had a contracting group at CERC. We had travel, we had shops, we had welders. We had all of the baggage that a full-fledged laboratory organization needs. We had an Instrumentation Division. When we came down here, WES had all of that. Now, granted, because of our relocation we added another $10 million worth of work to WES. So they did need a few people in the support organizations, but we put only 11 personnel spaces in the support elements of WES. The other personnel spaces stayed with CERC, with the laboratory. What really happened is that we hired engineers and scientists to replace some people who were in these support areas.

BG ROBERTSON: But that gives you greater capability and productivity for the dollar spent.

DR. WHALIN: Certainly. That's correct. Absolutely. No doubt about it. So we have 88 engineers and scientists out of 138 people. That's a high percentage. We also have about 20 technicians, and then there are secretaries and the management support group. We're really lean and mean.

BG ROBERTSON: And more productive.

DR. WHALIN: Yes. We are very lean. So we are very efficient. That's one of the advantages of doing something like relocating--it provides the opportunity for streamlining your organization--if you make maximum use of the opportunity, then the government and the taxpayer/citizen are winners.

BG ROBERTSON: Despite the trauma.

DR. WHALIN: That's true. I don't think the organization really suffered too much trauma in a total sense. One of the real saving graces for that was that we had the Wave Dynamics Division from WES' Hydraulics Laboratory to become a part of CERC. Those folks really worked about 150 percent of their ability for about a year to take up the slack during this relocation, and they just did a super job of it while we were hiring people in. The people that remained at Fort Belvoir that left on 30 September 1983 also need complimenting because they did a good job of getting a lot of reports out. They didn't just sit up there and draw their paychecks until September 30. They were very productive, and they need a pat on the back for that. We did give them a pat on the back.

BG ROBERTSON: One point of all this, too, for the benefit of the Board and the record, is to pat you people on the back who did make what could have been a very difficult and traumatic move relatively smooth as far as those of use watching from the outside at that time were concerned. I was involved, as you know, early on when the decision was in the process of being made, and we did foresee a great deal of trauma that did not occur. Overall it looks like you did a beautiful job on it. You and the rest of those who are involved, I think, need to be complimented.

DR. WHALIN: Thank you very much, but I had a lot of help from the total WES organization, really. So you see, we had all the administrative functions in place. We had a total team approach at WES to get this accomplished as effectively and as efficiently as possible. And we really did a good job, I think.

The personnel people were quite responsive. We hired over 80 people in about an 18-month period. Not all were engineers and scientists, but a lot of them were. Personnel delegated a couple people just essentially to me, to do whatever I needed done. The Personnel office really did a good job on it.

DR. LE MÉHAUTÉ: I want to point to something brought out in your presentation concerning National Science Foundation (NSF) support for coastal and ocean engineering which is less than $600,000. The housekeeping alone for the Duck facilities is $450,000. Therefore, there's nothing available for research. I just want people to keep that in mind. There is almost zero support for basic research in this whole technical area.

I orginally started my work in missiles, and this goes way back to 1946. What I want to point out is that when we started the amount of money that was available (and still is) was tremendous. Those problems are so much simpler than our problems. The ocean problems don't sound complex, but they are. The missile stuff is simple. The aerodynamics is simple. The head transfer was simple. You had these things under your control. we're dealing with things much more complicated, and yet we have just orders of magnitude less money to study them. I would like to use that as one of the platforms we go for when we go into our general discussion.

BG PALLADINO: First a comment and them a question. Dr. Whalin showed quite an array of the kinds of missions which are accomplished or addressed by CERC, the things which the Center does. I want to offer a compliment with regard to a couple of mission support activities which have been extraordinarily helpful and very sound technically, specifically the Fisherman's Wharf project which the Center addressed for us as we were almost in the bidding stage, and I think most of the folks are happy now knowing that we have awarded the contract. As far as Buhne Point is concerned, we had, last Saturday, the dedication; and Colonel Andy Perkins and I had the pleasure of joining the citizens there to see that completed project work and to see the pride in the local folks in terms of what the Corps has done. A great deal of that credit, in my view, belongs to the Station and the work done here.

Many of these provocative questions which you have posed, Bob, center on this issue of basic research. As a backdrop to that, I would offer a question, which perhaps others might want to address, and that is the climate in terms of demand for basic research in this area. I fully recognize that it's the kind of thing where you put money into a program without defining what it is you expect to get out of it. You offer a resource where the best minds in this Country or any country can develop what eventually might be something which could be applied. *But specifically, Bob, does CERC, receive proposals for basic research which you must turn back simply because of inadequacy of funds? Is there in the community—the academic community—the dredging community and others a swell of basic research requirements which for a whole variety of reasons aren't being funded? What is the backdrop against which we might be able to make some judgments in terms of moving in that direction?*

DR. WHALIN: As Dr. Le Méhauté said there is essentially no money now available for basic research, and there are critical needs. If we were to get an extra $10 million for basic research--which I know we're not--we'd contract all of it except what it costs to monitor, and we'd contract primarily at the universities. I am quite concerned about the fact that we're just not funding the academic community where the majority of our clever, innovative technological advances are normally made. By we, I mean the coastal engineering profession, or anyone. Nobody's funding it, and we're all going to be short-changed.

The demand for those products is very difficult to put on a piece of paper and justify. An advance in our technology--our ability to understand coastal processes better because we understand the physics of sediment movement and wave sediment interactions better--probably would enable us to make a quantum leap forward in the accuracy and reliability of our coastal project design. We certainly need some advancement in our measurement technology which should lead, without a doubt, to better solutions for our coastal problems. We ought to be able to maintain our coastal navigation channels better if we understand the physics of what's causing them to shoal up better. If we're able to predict shoaling processes better, we can devise better solutions for maintaining our navigation channels, probably cheaper solutions too. That usually tends to come with knowledge. I defer to Professors Wiegel and Le Mehaute to make some comments about that.

We're really squeezing the last bit of benefit out of our existing engineering/scientific technology. Our computers are getting faster, we're crunching numbers faster, and our numerical technology is increasing. Our laboratory is getting better. Let me rephrase that. We're now catching up in CERC and in coastal engineering with the rest of the world, and we're very close to them. Some of us think we're going to pass them very shortly in our laboratory technology for coastal problems.

I think an increase in our basic research will lead to tremendous dollar savings in almost everything the Corps does in coastal projects. In O&M, and in the dredging projects, there will be better designs. There will be more cost effective structures. The things we tend to fund now in the research programs are applied research or development work units with immediate applications. And you know, that's the way the budgetary climate is. I'm not complaining; I'm stating facts. I'm not sure I've really answered your question well.

BG EDGAR: Let me interject something here because I think basic research is one of the things we want to address in our discussion, given not only the question that Don has posed but also those in our general discussions at other times. Let me try to put things into focus, and then we can open up the discussion because I believe the more we talk right now, the more we are going to get into some of these provocative topics. We need to be sure we have a handle on what we are talking about and the constraints within which we have to live. Robert, I am going to ask you to be the facilitator of the discussion.

DR. WHALIN: Yes sir.

BG EDGAR: Before we do that, I want to remind everybody of some things that Bill Roper had in his presentation insofar as our current coastal engineering research and development (R&D) policy exists right now. You may want to turn to his presentation and keep that in front of you as we go through. Those six points he emphasized essentially said coastal engineering R&D (1) is mission oriented to support civil works; (2) has close user interaction with the field and OCE; (3) exploits new technology to benefit the Corps mission; (4) places emphasis on user application and technology transfer; (5) maintains/enhances Corps technical credibility through high quality, useful R&D; and (6) maximizes benefits to the Corps from mission support programs.

Now given all of that, if you go back to the thoughts that I gave you as we began our session this morning you will discover that we now have in the CERB charter that the CERB (1) provides broad policy guidance and review of plans and fund requirements for the conduct of research and development in the field of coastal engineering; (2) recommends priorities of accomplishment of research projects in consonance with the needs of the coastal engineering field and the objectives of the Chief of Engineers; and (3) performs additional functions as assigned by the Chief. That last one allows us to have the kind of discussion that we are beginning this afternoon.

Now tied in what all of that is the fact that CERC now resides here at WES with a far greater capability--given the multiplicity of facilities that are here--than what it has ever had before. It was a capability to participate in some things that perhaps they had not otherwise been able to do because of proximity when it was located a thousand miles or so away. We've also got to take into account, I think, dollars. Bory Steinberg pointed out before and Robert put up on the screen just a few moments ago some figures concerning the dollars with which we have to deal within the R&D activity. If we were to recommend that certain things be done beyond that which we're doing now, we're going to impact the activities of Lew Blakey, Cecil Goad, or others.

And I'm not saying that is not what we want to talk about today. We most certainly want to do that because that is why we're here. However, the reason I wanted these folks to be here is so that they can address what we say from their perspective, too, because they also have priorities which are very important to their mission in life.

So I hope that our presenters of the morning and of the afternoon will enter into full discourse in our discussions here with the Board. Please feel free to do so because the results of what I hope to see from our discussions today and the rest of our time here in Vicksburg are some recommendations to the Chief which make sense for the betterment of the Corps and for whatever mission area that we're talking about. In any event, I think that the discussions that we will have will be healthy and are long overdue. Robert, you posed some provocative questions. Let's take it from number one and go on down, and then we can refer to your budgetary slide if you want to, i.e., if a question comes up with respect to that.

At this point Dr. Whalin facilitated a lengthy, energetic, and enlightening discussion. The following is a synthesis of the discussion on each of the major questions or topics addressed. All questions in Dr. Whalin's paper were not addressed; however, other questions or topics evolving from the discussion were addressed.

Question

Should the Corps fund more basic coastal engineering research?

The unanimous answer from the Board, principal OCE and WRSC staff and other participants was yes.

MR. GOAD

Mr. Goad asked if the Corps had the authority to conduct basic research.

DR. BLAKEY

Dr. Blakey responded that there were no prohibitions he was aware of. It was Dr. Blakey's opinion that research the Corps would conduct would not be "basic" research as the academic community would define it. It would be something "less than applied".

MR. PFEIFFER

Mr. Pfeiffer agreed with Dr. Blakey and defined the research as development of "fundamental knowledge" that is necessary to understand coastal processes.

DR. LÉ MEHAUTÉ

Dr. Le Méhauté strongly supported the need for basic and/or fundamental research. He noted the primary purpose of basic research is "to maintain a level of capability". He said that without basic research the Corps level of capability will decrease.

MR. OLIVER

Mr. Oliver said that the Corps is now working with existing harbors and forecasting for future harbors with data sets that are only "within an order of magnitude of the right answer. That is a factor of ten!" It was his opinion that if the basic or fundamental research was not conducted to improve the confidence in the numbers, tremendous opportunities will be lost and huge under or over designs and project costs will result. He summarized his thoughts with "without research I don't see how we can progress. We can do all kinds of things to make more sophisticated models to handle equations that are very unsophisticated. We need the answers, and the only way to get them is through basic research." Mr. Oliver noted that the coastal processes studies he has heard discussed parallel studies that are mainly for dredged disposal. He suggested closer coordination of such studies.

DR. LE MÉHAUTÉ, PROF. WIEGEL, AND DR. NUMMEDAL

All addressed a point raised earlier concerning how many unsolicited proposals are funded by CERC. The answer is very few since it is well known that little funding exists at CERC for such studies. Nobody wastes time and effort preparing proposals when there is little or no possibility of success. All noted there were many good ideas out there that will never be brought to bear to solve coastal problems.

Question

How will the research be funded and for how much?

DR. BLAKEY

Dr. Blakey noted that about 45 percent of the construction program involves construction in the coastal areas. About 10 percent involves near-shore restoration. He concluded that one could then make the case that 45 percent of the research dollars should be earmarked for coastal studies. Shore restoration research would account for 10 percent of the research dollar.

Dr. Blakey reinforced BG Edgar's statement that it is a zero sum game with regard to General Investigations Research and Development (GIR&D) funds. In his opinion there will not be additional funds allocated for general investigations. Therefore, if we increase GIR&D, other GI functions will suffer. He suggested that perhaps Construction General (CG) funds would be appropriate for some R&D.

BG ROBERTSON

BG Robertson followed up on Dr. Blakey's thoughts on the percentage of projects in the coastal areas equating to the percentage of R&D dollars going into coastal engineering studies. He suggested that we identify R&D needs for those projects now and get started. He cited projects that were delayed after authorization because of information gaps that required up to 5 years to fill. Consequently, he said, "we must come up with some way to justify funding necessary to get those data so that when the authorizations and appropriations come we don't have to wait another 5 years and add to the Corps' image of not only being expensive but slow."

MR. GOAD

Mr. Goad reviewed the O&M budget he oversees and noted there was a significant difference in the problems just stated by Dr. Blakey concerning the GI budget and his O&M budget. He said the O&M annual budget was in the order of $1.3 to $1.4 billion with a year end carry over in the $91 million range. He said O&M funds for most research are not a problem. However, because of the way the O&M budget is derived, there must be a connection to the project. He cited the REMR program as an example of a multi-million dollar research program funded out of O&M funds. REMR will produce results that will reduce the cost of doing O&M business. He said, "there may be other REMR's around some place that need to be developed."

BG EDGAR

BG Edgar noted that when he was a Division Engineer he came to Mr. Goad with the Field Verification Program (FVP). The FVP was established to lower the cost resulting from environmental constraints on dredging and dredged material disposal. The FVP is funded at the multi-million dollar level with O&M funds. He stated that the "key is to package your needs and to put them up front early...." You must get the right people "enthusiastic" over the work.

MR. MURDEN

Mr. Murden discussed an approach to funding where the R&D associated with a project will more than pay for itself. He cited a case where a berm (later referred to by most participates as "Murden's Mound") constructed near the channel with dredged material could produce significant savings over disposing of the material in the ocean miles away. Research and monitoring will be required in order to establish the feasibility and environmental impact of the approach. He used a dredging project in the Norfolk District as an example. He stated that a 21-mile one-way haul could be eliminated at this site by using the adjacent berm concept. This would result in an $800,000 to $1,000,000 cost savings of funds presently allocated for this project. He proposed that these funds be allocated for the R&D and monitoring necessary to implement the concept. If the concept proves out, Mr. Murden said over $50 million could be saved with the proposed Norfolk Harbor deepening project. He suggested that this is but one example of creative financing.

Mr. Murden said that if the R&D project such as he outlined resulted in significant savings, he agreed with Dr. Blakey that the "next step up the ladder" would be to go to the (CG) budget.

Mr. Murden noted there were many striking similarities between the dredging and coastal engineering programs. He said that each had a relatively small number of professionals with true expertise in the field and that little or no basic research was being accomplished in either field. The two fields are obviously interrelated, and every effort should be made to conduct joint studies that are substantially beneficial. He agreed with Mr. Oliver that studies in the two fields should be closely coordinated.

MR. LOCKHART

Mr. Lockhart noted that many of the Corps projects are beach erosion projects. These are considered under construction for the life of the project. He concluded it was logical to use CG funds for obtaining data on these sites.

MR. PFEIFFER

Mr. Pfeiffer stressed the word "innovation" in funding R&D. He agreed with tying R&D to specific projects. He cited the dolos study in Northern California as an example of obtaining information that "will be new to the world" from a "real world project." The R&D is being funded by the O&M budget because they can "stop forever repairing these dolosse every 5 years."

BG EDGAR, BG PALLADINO, DR. NUMMEDAL, AND DR. WHALIN

BG Palladino brought up the role of the NSF in funding basic research and asked what the Corps relation with NSF was. BG Edgar wanted to be sure there was coordination with NSF so we don't "reinvent wheels." He said coordination was also needed with other agencies such as the Navy and NOAA. Dr. Nummedal saw the potential for joint funding with NSF to accomplish R&D that was of mutual interest to the agencies. Dr. Whalin agreed and thought we should actively pursue more joint studies with NSF and other agencies. BG Edgar asked that the Director of Research and Development follow up on assuring there is proper coordination with the other agencies.

Question

How should basic R&D be accomplished?

DR. WHALIN

Dr. Whalin had addressed this issue earlier to some extent and recommended that the basic R&D be conducted by the academic community.

PROF. WIEGEL

Professor Wiegel agreed with Dr. Whalin and expressed his philosophy as follows:

> If you're looking for new ideas and new techniques on ways of trying to answer questions, historically this has been done better in universities for very good reasons. You have bright people there who are enthusiastic, young,

and energetic. Furthermore, when you're working with them, choosing a research subject, you match that person with a project, and then that person has to take several years of courses, including the most recent information given in the math department which is an advancement over anything out in industry. That person is expending a tremendous amount of his/her own time and effort in developing the capabilities to resolve that problem.

Now if you're a full-time research organization, you almost never can devote that sort of effort to bring a person's talent to bear on the solution of a problem. Furthermore, that person will spend probably 2 years just aimed at that one thing, quite likely the most intensive intellectual effort that person will ever undergo in his or her lifetime. So we can make a major step forward.

As far as the "D" part--the "development" in research and development--is concerned, not often can a university apply results directly to the solution of a problem of such as putting the dolosse in at Crescent City or some place. That requires a different type of sustained effort, and that's the kind of effort that a laboratory, such as CERC, WES, and the commercial laboratories (such as the one GE) are best at. I think that we should recognize that both of these activities are needed for us to go forward and then try to put an appropriate amount of money--and I think most of it should be on contract--out to various universities.

Furthermore, you've got management capabilities here. You're not trying to keep people employed in-house because you have a staff. You're trying to solve certain specific problems which come in from the operating Divisions or Districts. So you see that a particular university seems to have a combination of people right now who can work best on that problem, and then they work on it. Now, what you want to do is change a little bit. There is another group that seems, in your opinion, to have the basic capabilities, so you now move and you support that group. You give yourself a lot of extra flexibility there.

QUESTION

Should the Corps establish a large center of excellence?

DR. LE MÉHAUTÉ

Dr. Le Méhauté said the Corps already has a large center of excellence in CERC. He noted CERC is the only center of its type in the United States. He said the question then should be, "what additional facilities are required at CERC?" He noted that great centers have some unique capabilities. CERC has a directional spectral generator unique to the United States. The Corps should look to establishing other unique capabilities at CERC. He said that regardless of what additional facilities are acquired, the Corps must make a long-term commitment to acquiring and maintaining a highly qualified technical staff.

QUESTION

Should the Corps update the National Shoreline Study?

DR. LE MÉHAUTÉ

Dr. Le Méhauté said the study was very useful but that in retrospect economic aspects were missing and should be addressed. He thought that the California and Florida studies could be extended as a first step in updating the National Shoreline Study.

BG EDGAR

BG Edgar asked if Congressional authorization was required to update the study and what the cost of the update would be.

DR. BLAKEY

Dr. Blakey said another authorization would be needed to conduct a "full blown" study. An option would be Dr. Le Méhauté's suggestion of expanding the the two state studies. He noted that you can't find "program" supporters but you can find "project" supporters as illustrated by the two ongoing state studies. He doubted if funds could be found for a total update. When pressed by BG Edgar to estimate the cost of the update, he said at least one million dollars would be necessary.

COST SHARING

The topic of cost sharing was discussed at some length and the following is a summary of the discussion.

BG Edgar said cost sharing with local sponsors will require more definitive initial studies conducted in a relatively short period of time. He doubted if local sponsors would buy into projects after only very cursory studies had been conducted. Therefore more money for studies "up front" will be needed. Professor Wiegel said often a "bathtub" approach was needed. By this he means taking a quick look at some aspect of the problem. Approaching problems in this manner is difficult when dealing with the Federal government because of the "cumbersome" contractural requirements. Mr. Hagen said he had found it difficult to get researchers to give "quick" recommendations. BG Edgar and Dr. Whalin agreed that in many instances quick recommendations are needed, and the R&D community will have to change their way of doing business in this regard. Mr. Wanket agreed quick answers are needed but doubted if substantial increases in up front funding would be forthcoming to do studies with expanded scopes. BG Robertson said with the local sponsors involved more "Ford" projects will come about as compared to the "Cadillac" projects we now have. Therefore, we should expect more failures and be ready to develop techniques to understand "why" they failed. We must learn from mistakes that will be made. Mr. Hagen agreed that more investments in monitoring existing projects must be made. Dr. Blakey said the whole planning process was in a "revolution" with the advent of cost sharing. There will be many decisions made in the near future and significant changes in the planning process and types of funding will probably occur. BG Palladino thought cost sharing may provide another funding alternative for R&D. He suggested approaching the local sponsors on R&D efforts that will result in savings to them. BG Edgar summarized this discussion by saying that we will be pressed to do work quicker and faster, but in the end it must be a "quality product."

CRESCENT CITY DOLOS PROJECT

CERB Proceedings

Dr. William L. Wood, Chief
Engineering Development Division
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Mr. Gary L. Howell
Research Hydraulic Engineer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Mr. Robert A. Cole
Research Structural Engineer
Structures Laboratory
US Army Engineer Waterways Experiment Station

ABSTRACT

At present there is not a design procedure available to coastal engineers for the prediction of structural strength requirements for dolos armor units. As armor unit sizes have increased, structural failures have increased in frequency. Several major failures of breakwaters around the world have been attributed to dolos structural failure. The objective of the Crescent City Dolos Project is to obtain high-quality data on the forces, motions, and resulting structural stresses of dolos armor units in a high-energy prototype environment. As part of the study, an international workshop was held to review the state of the art in structural investigations of dolos. The unanimous conclusion of the workshop was that detailed prototype studies, such as that at Crescent City, were necessary before further development of design methodology could be accomplished.

INTRODUCTION

Since dolosse were introduced in the mid-1960's (Merrifield and Zwamborn, 1966 and Merrifield, 1968), they have continued to grow in popularity. In the intervening years numerous articles have been published, and the very recent ones (e.g. Costa, 1983) have addressed the complexities of the dolos structural modeling problem.

The dolos armor unit has proven to be an economical and effective tool for breakwater construction by the Corps of Engineers (Corps). However, due to several recent catastrophic failures of dolos breakwaters in other countries and high breakage rates of dolos units on Corps breakwaters (Markle and Davidson, 1984), there has been increased concern about the structural strength of the dolos unit. Previous assumptions that hydraulic stability of a breakwater design was sufficient to guarantee structural strength have now been called into question. The lack of a structural design procedure to predict required armor unit strength for a given breakwater design creates a difficult situation for District breakwater designers. A design procedure requires analysis of structural forcing functions due to waves and impact loadings in the breakwater environment. Efforts to date to develop a design procedure by analytical methods, laboratory scale models, or numerical models all suffer from the lack of prototype data required to provide necessary boundary conditions and verification.

The Crescent City Dolos Project will provide a comprehensive data set on prototype scale 42-ton dolos armor units to be fabricated and installed as part of the rehabilitation of the Crescent City, California, harbor breakwater. The program is comprised of an intensive monitoring effort which will measure structural strains during all phases of the life of a dolos from casting through transport, placement, settlement, and eventual exposure to storm wave conditions. Numerical finite element modeling will be used to interpret the measurement results and provide the basis for the structural analysis of the dolosse under prototype support and loading conditions.

PROTOTYPE FIELD MEASUREMENTS

Prototype data from the Crescent City Dolos Project will be derived from 20 special dolos armor units which will be instrumented with internal strain gage assemblies (Figure 1). The strain gages will be configured to measure the moments and the torque about one shank-fluke interface. Coincident with the stress measurements, the velocity of motion of six of the dolosse will be measured with 6 deg of freedom. Velocity data may be used to determine impact energy for correlation with sea state and resulting stress. Offshore directional wave measurements as well as scalar wave measurements will be made near the breakwater. Hydrodynamic pressures within the core material, along the face of the cap and within the dolos matrix, will be measured also. A description of the measurement plan was presented at the 41st Meeting of the Coastal Engineering Research Board (Domurat and Howell, 1984).

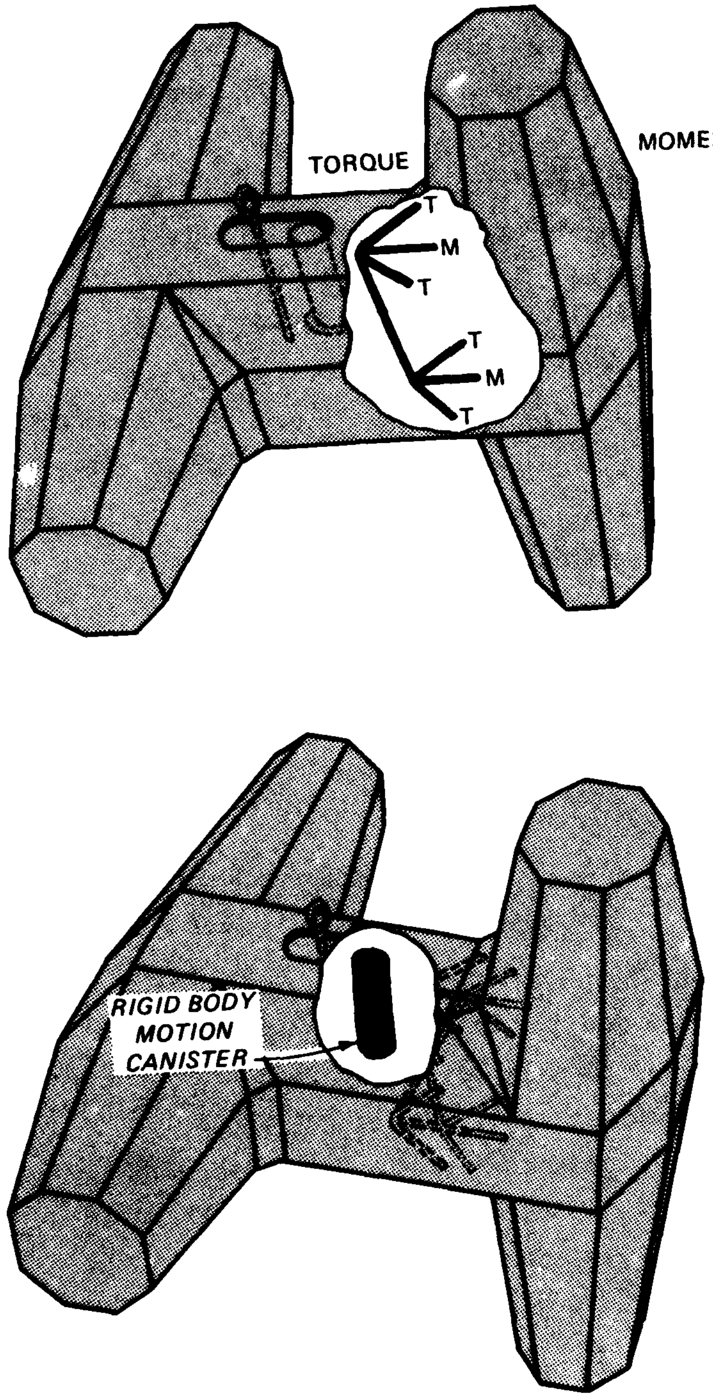


FIGURE 1. INSTRUMENTATION OF DOLOS

Measurement Strategy and Interpretation

As a result of recommendations by the dolos workshop, data acquisition procedures for the field measurements have been expanded to assure the description of pulsating stresses, as well as impact and static stresses, and strains on the time scale of wave periods. In accordance with the convention of Burcharth (1984), total stress will be considered as the summation of static, pulsating, and impact stresses. Pulsating stresses are those defined to be on the same time scale as wave periods; whereas impact stresses are on the time scale of the fundamental vibration modes of the dolos. Prototype data will be analyzed to create a statistical distribution of each component of stress as a function of sea state. Such an analysis would result in an empirical description of the hypothetical curve suggested by Burcharth (Figure 2).

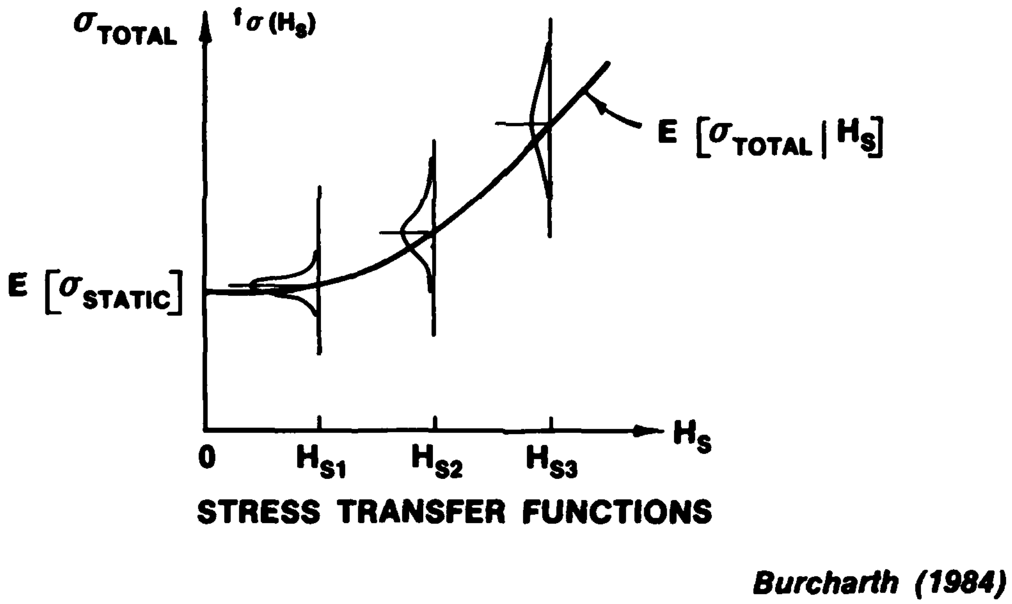


FIGURE 2. QUALITATIVE ILLUSTRATION OF DEPENDENCE OF STRESS TRANSFER FREQUENCY FUNCTIONS ON WAVE PARAMETER

Placement of Instrumented Dolosse

During the initial phase of the study, several placement plans have been proposed, evaluated, and reviewed. Final candidate strategies were discussed in detail at the Dolos Workshop. A consensus has emerged favoring a placement strategy which would group all instrumented dolosse together in a single matrix. The strategy is based on the requirement to identify the surrounding boundary conditions of each instrumented dolos as well as the need to have a statistically significant number of measurements from dolos exposed to the same, or nearly the same, wave environment. Although the importance of spatial sampling of conditions affecting dolosse at other points on the breakwater is recognized, it is felt that the difficulty of determining and comparing wave conditions along the breakwater will make comparison of results from widely separated dolosse difficult. Similar considerations of the importance of characterizing the incident wave conditions led to the decision to place the instrumented dolos matrix near the middle of the trunk section of the breakwater. The exact position has been selected based on considerations of cable protection and installation. The instrumented section is a 4 by 5 matrix with the six accelerometer dolosse placed on top and in the center. The matrix is centered at the mean water line.

Dolos Cable Protection

During the fall of 1984, a test of proposed cable protection systems for the instrumented dolosse was conducted at Crescent City. The primary system tested was modified anchor chain. Chains (in sizes up to 3 in.) weighing from 70 to 80 lb/ft were used. The primary purpose of the chain assemblies was to form an anchor system for the dolos signal cable coming up the breakwater to the cap. Various methods of attaching the cable to the chain were implemented, including holes, clamps, and bindings. Additionally, a single armored cable was deployed without chain.

After subsequent inspections, it was determined that the chain assemblies did not move during mild to moderate wave conditions. Attempts to inspect chain motion during severe wave conditions were unsuccessful; however, indications from other inspections indicate little, if any, movement due to wave action. The armored cable did show cyclic motion during moderate conditions, indicating that cable fatigue failures of unanchored armored cable would occur. None of the methods employed to attach the cables to the chains proved to be entirely satisfactory. The method in which holes were used in the cable caused too much stress to the cable due to the multiple sharp bends. The method in which straight run of cable was used along the chain was the most satisfactory, except that the attachment methods either failed or were too time consuming to install. An additional problem learned from the test was the possibility of damage to the cable during installation due to the ability of the chain to bend at a sharp angle, thus forcing the cable below its minimum bend radius.

Based on the results of the test, it was decided to use a modified anchor chain as the cable protection. The chain will be modified such that cable can be attached along the chain without bends. Additionally, this modification will restrict the bend radius of the chain to a 24-in. minimum. These modifications are presently under test and evaluation in the laboratory.

Dolos prototype instrumentation was dictated in large part by breakage experience (Figure 3). One of the disadvantages of using prototype measurements, however, lies in the difficulty associated with successfully recording data. Despite deployment of only a limited number of instrumented dolosse, the amount of data being collected is astronomical. Consequently, a method must be found to condense this information into usable form and to interpret the collected data. Finite element analysis can be used to complement prototype measurements to solve these problems associated with structural modeling of dolosse.

FINITE ELEMENT ANALYSIS

Analyses of dolosse relative to structural modeling problems have been performed for a number of years. Harris (1974) did an analysis based upon simple assumptions. Lillevang (1975) did excellent work based upon photoelastic methods. In 1976 he used these same methods in a collaborative effort with Nickola. Strength analyses of dolosse have also been performed in the past, and the work has been documented by many authors, including Harris (1974) and Merrifield (1968), most of whom express divergent points of view.

Finite element analysis has been treated as the new approach to the strength design of dolosse. Steps involved in a finite element analysis are illustrated in Figure 4 which shows a block diagram for a "system." For a known "system" there is a transfer function $C(S)$. For a given input $R(S)$ the calculated response is $Y(S)$. In this case, the "system" is a dolos unit which consists of the geometry which defines the dolos and the boundary conditions which define how the dolos is supported. The boundary conditions are not, hopefully, a function of time. The material model could be a simple linear/elastic model with a modulus and a Poisson's ratio or a complicated nonlinear model with many model parameters.

Inputs consist of the forcing time history that constitute the loads on the structure and/or initial conditions such as initial velocities. In this case, flow stresses are generated by lift and drag forces as water flows

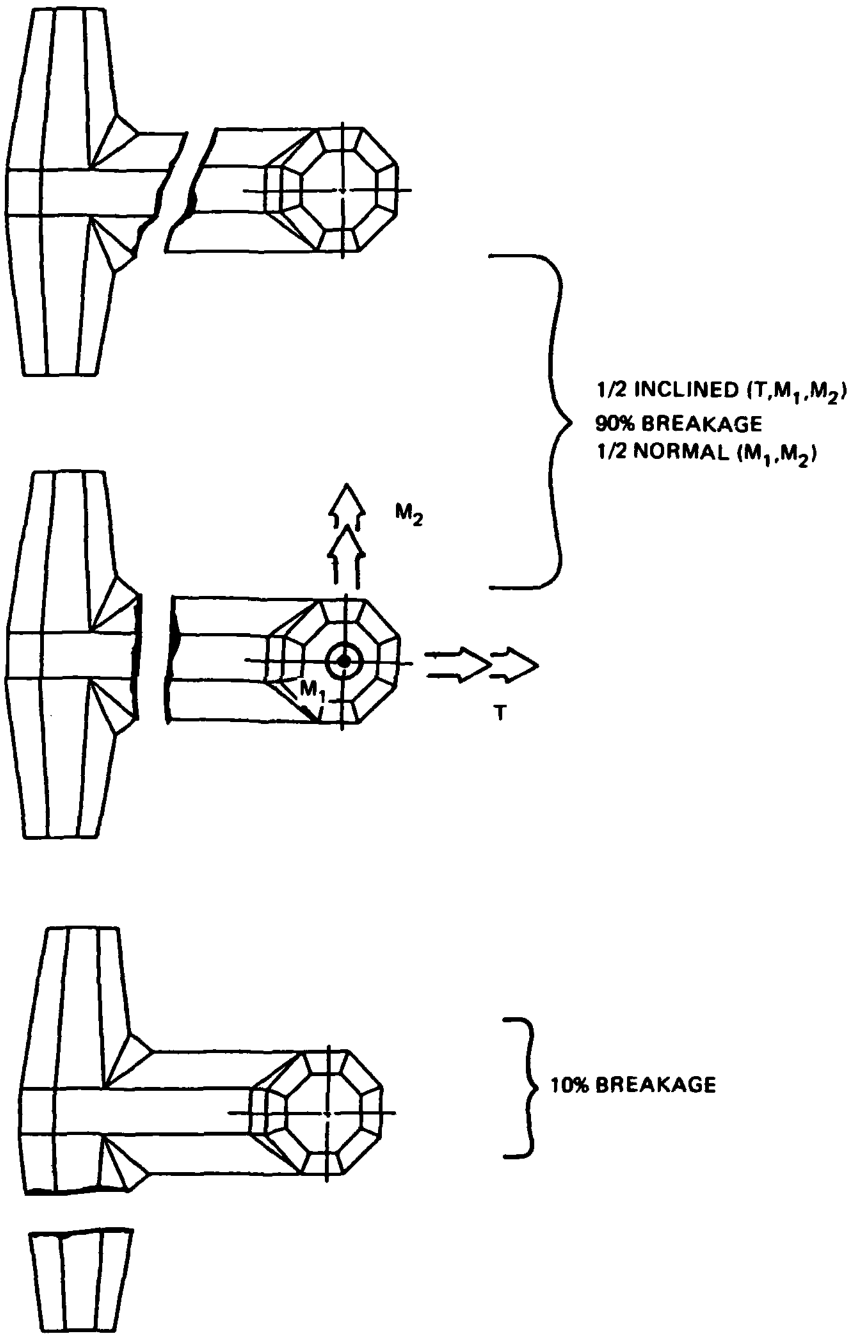


FIGURE 3. DOLOSSE BREAKAGE EXPERIENCE

1. STEADY STATE - FLOW
2. TRANSIENT ANALYSIS - IMPACT
3. Σ 1 & 2

$$R(S) \longrightarrow \boxed{C(S)} \longrightarrow Y(S)$$

$$Y(S) = R(S)\,C(S)$$

THE SYSTEM C(S):

GEOMETRY
BOUNDARY CONDITIONS
MATERIAL MODEL

THE INPUT R (S):

FORCING TIME FUNCTIONS (LOADS)
INITIAL CONDITIONS

THE OUTPUT Y(S) AT ONE OR MORE AREAS OF INTEREST

MOTION HISTORIES
FAILURE CRITERION = f (STRESS HISTORIES)
MOMENT, THRUST, ETC HISTORIES (DESIGN)

FIGURE 4. FINITE ELEMENT ANALYSIS PROBLEM

through the dolos bed. Impact stresses are caused by the response of the structure to an initial velocity distribution at the moment of impact.

Output results consist of motion histories, accelerations, velocities, and displacements. Element output can consist of stress histories for brick-like element or moment and thrust histories for beam elements. The element output even for the simple linear material model must be related to a material failure law.

If a linear model is suitable and the boundary conditions are easily defined, a straightforward eigenvalue extraction can be performed. With these mode shapes (Figure 5) a solution is sought which is a combination of these modes. If the model chosen is nonlinear, then a time matching integration scheme is required. Fortunately sometimes the system can be characterized by a single-degree-of-freedom; that is, the response is represented by a fundamental mode. In other cases multimode solutions are needed when the geometry and boundary conditions dictate.

The finite element method and related methods of analysis are well

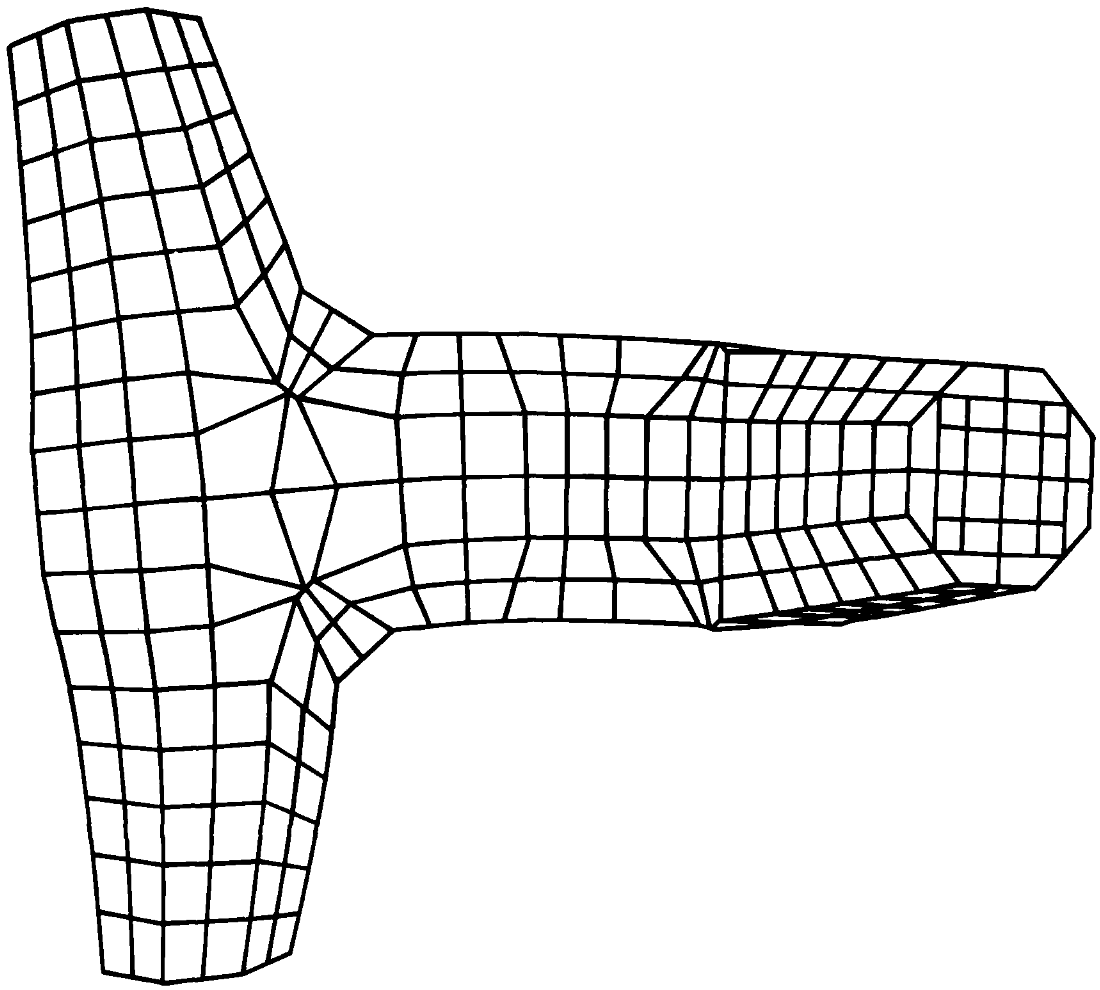


FIGURE 5. DOLOS FINITE ELEMENT MODEL WITH CHAMFER (mode number 5)

suited for deterministic problems which have a well known and finite set of loads and well determined boundary conditions. The structure geometry can be rather complex, but there is usually a specific area where output is desired. Also there is a design objective, such as determining minimum thickness or ultimate load capacity. Usually in these deterministic problems a "worst case" approach is considered.

The dolos structural problem fits into this scheme because the dolos is a structural shape that is simple and complex at the same time. It is simple in that it is homogeneous and not made of subshapes. In fact, it is only necessary to model one-fourth of the dolos. The total grid can then be based upon that fraction. A dolos structure is complex in that it has an octagon-shaped cross section and flukes that are at right angles to the shank and offset 90 deg from each other. The dolos may or may not have a chamfer.

Concrete must be modeled as the material. Fortunately its nonlinear behavior does not have to be modeled because when concrete exceeds its linear behavior, it starts to crack; and the ultimate objective is to have dolosse that do not break. There is much to be learned from linear analysis.

The problem of modeling dolosse becomes complex when boundary conditions are considered. The dolos in an armor layer has an infinite number of orientations and support conditions. The same thing can be said about the loads. From an analysis point of view, this is where the problem really lies.

A few final comments about finite element analysis. First, finite element analysis only approximates actual occurrences. Secondly, a large finite element grid can take a lot of computer time for one simulation. Conducting finite element analyses is like conducting a large experimental program. A lot of data are generated, and the data need to be generalized and reduced to a coherent form.

Design

Since the ultimate objective is a better design procedure, a discussion of strength design is in order. Currently design is hydraulic. Application of the Hudson formula with a stability factor determines the dolos weight, hence its size. Hydraulic model studies, when done, have helped design slopes, toe details, and rubble rock details. Material selection has been limited to concrete. The design choice has been dictated by cost since there is no cheaper mass material than concrete.

Strength design of dolosse has been an open parameter. The general feeling is, however, that dolosse should be made stronger. Studies have been done on casting and transportation to the site. These studies have all indicated that good casting and delicate handling of dolosse are essential. Chamfer and radius have been recommended for the shank/fluke interface. There has been much debate about whether to reinforce dolosse or not, and questions have been raised concerning fatigue (cyclic stresses), impact stress (motion), and abrasion resistance. These questions and many others still remain rather subjective.

Up to this point dolos strength has been discussed as a generic quality. As long as a dolos is considered a homogeneous concrete with or without "fibers", one would expect this dolos to be built with the same strength requirement throughout. It would be difficult to do otherwise. If dolos strength is going to be increased with rebars, then it becomes important to realize that a dolos does not have to be the same strength throughout. In fact, a typical designer needs to know the moment, shear, thrust, and torque distribution along the shank and fluke. Since the dolos is symmetrical, in a sense, it is necessary to know only the design shank distribution for one-half and the design fluke distribution for one-half of a fluke. The mirror-image portions of the shank and flukes for this design case would be designed as shown in Figure 6.

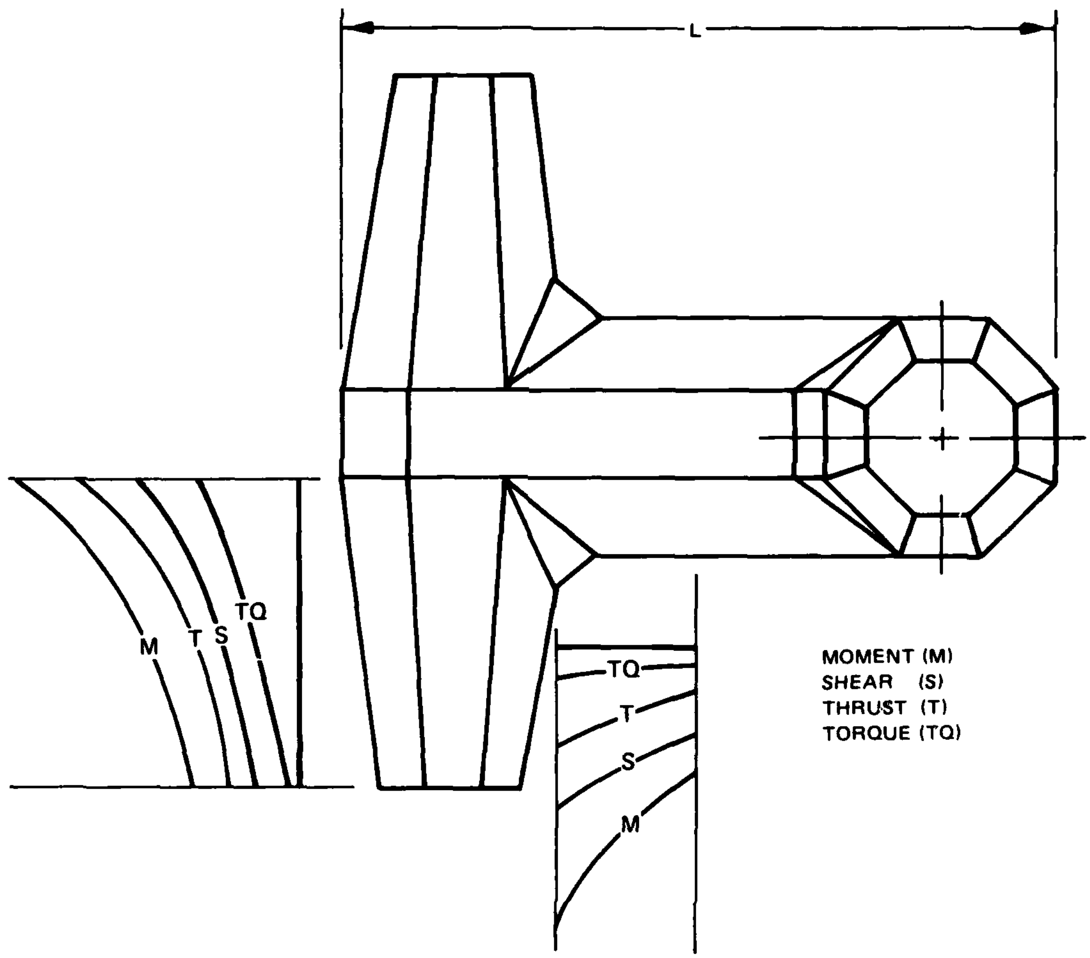


FIGURE 6. LOAD DISTRIBUTION REQUIRED FOR REBAR DESIGN

The design case for the shank and fluke may not be the worst case such as that for a typical deterministic design. The worst case may happen only once in 1/1,000 times. A design case needs to represent the cases which occur most frequently that keep the requirements within nominal breakage. Generally nominal breakage, besides being a function of life expectancy, could also be a function of dolos application. As the size of the dolos increases, the nominal breakage allowed might have to decrease.

Finite Element Approach

Two very detailed finite element grids, one with a chamfer and one without (Figures 7 and 8) have been constructed with brick elements. Finite

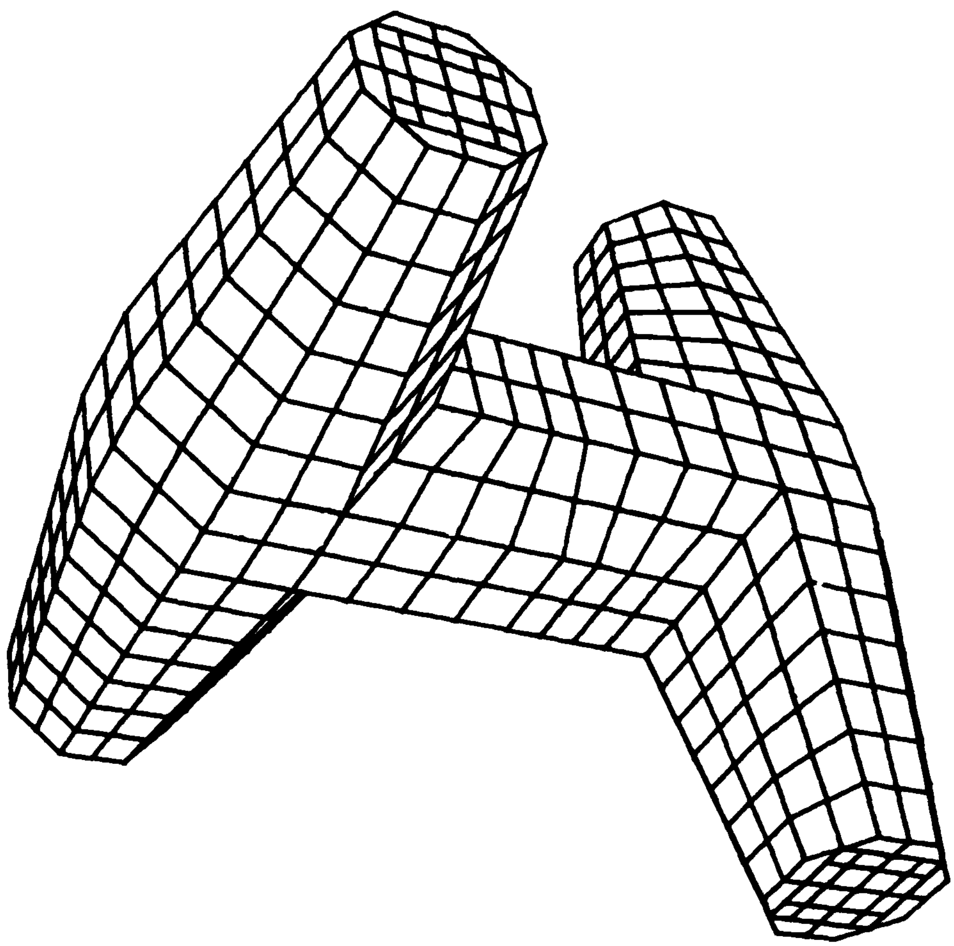


FIGURE 7. DOLOS FINITE ELEMENT MODEL
(undeformed grid)

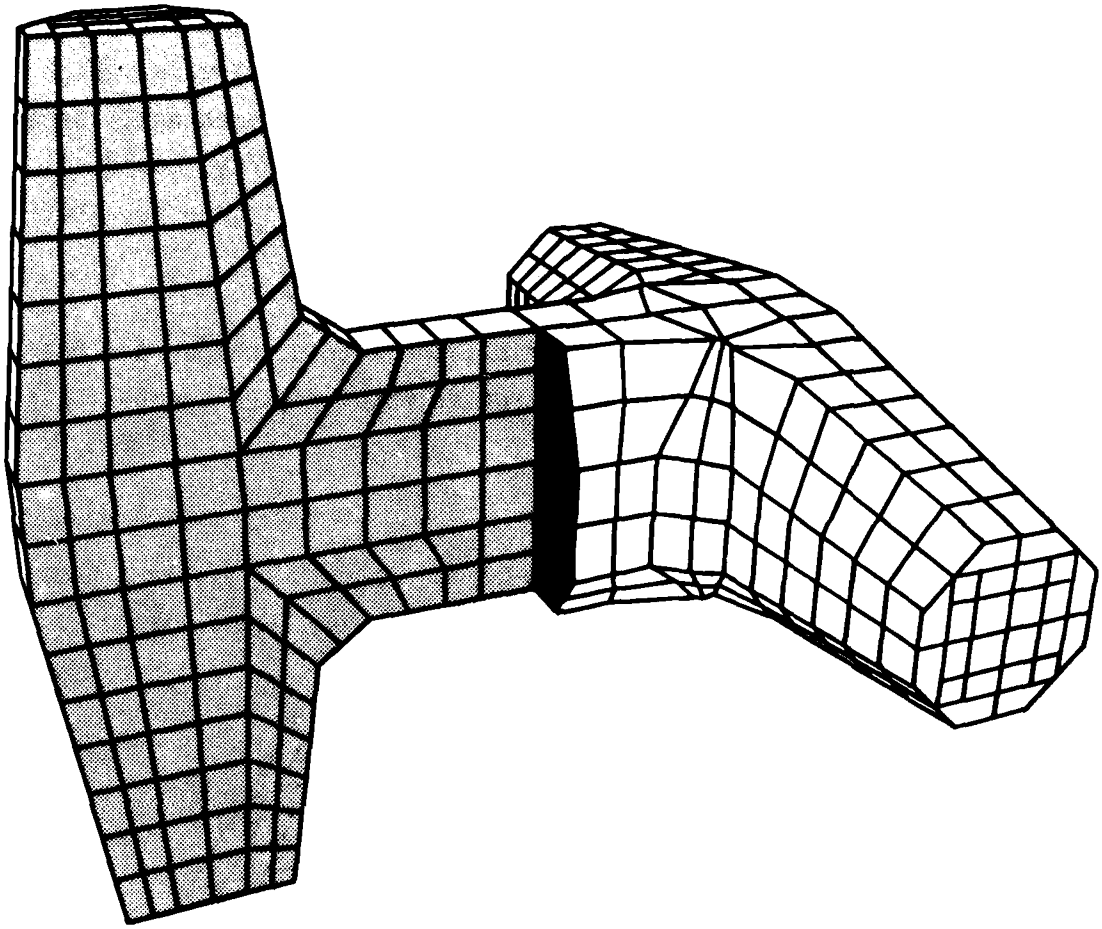
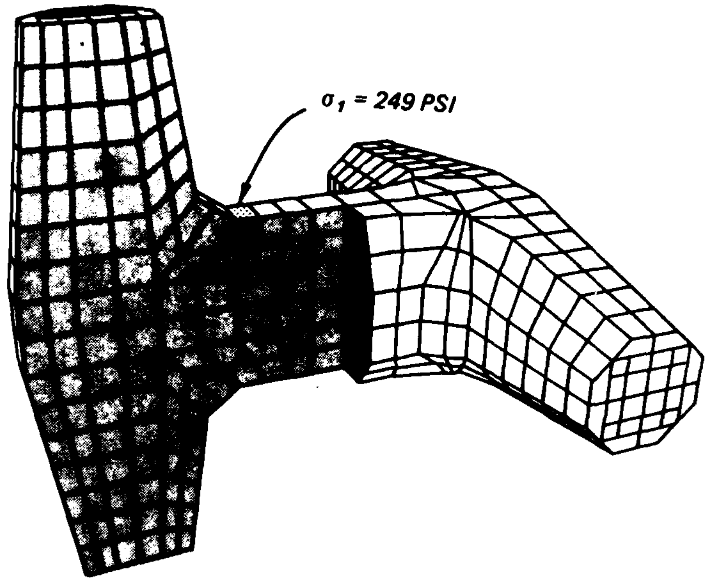


FIGURE 8. DOLOS FINITE ELEMENT MODEL
WITH CHAMFER (undeformed grid)

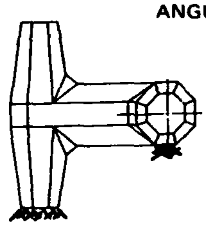
element runs have been made comparing Burcharth drop tests (Burcharth, 1981) and Terao, et al. (1982) static tests. These results look quite promising and are summarized in Figures 9 and 10. A method of calibrating analytical results with physical tests to relate analytical models with failure has been perfected. When modal survey tests are done, a method of calibrating the dynamic characteristics of the dolos will be possible. The modal survey test is a method of experimentally measuring the vibration modes of a structure.

A simpler grid with beam elements has been constructed, as shown in Figure 11. It is not as elegant as the brick element grids, but it is a simple finite element analysis to compute. It requires less computer time and human resources; hence, it can analyze many conditions. Also it has the advantage of primary element outputs of moments, thrusts, shears, and torques.



TEST PARAMETERS

L = 1650 MM = 64.9 IN.
DROP HEIGHT= 153 MM = 6.02 IN.
1.5t = 1500 kg = 3307 LB_f
ANGULAR VELOCITY AT IMPACT



$$W = \sqrt{\frac{2Mgh}{I_o}} = 1.86 \text{ ROD/SEC}$$

$$\text{DYNAMIC F.E. ANALYSIS} \left\{ \begin{array}{l} W_1 = 116.6 \text{ htz} \\ W_2 = 242.5 \\ W_3 = 340.14 \end{array} \right.$$

SCALE RELATIONSHIP

$$W_p L_p = W_m L_m$$

$$f'_c = 28.9 \frac{N}{mm^2} = 4191 \text{ PSI}$$

$$\text{MEAN STATIC STRESS} = 29.5 \frac{N}{mm^2} = 428 \text{ PSI}$$

FIGURE 9. CALCULATIONS FOR
BURCHARTH DROP TEST

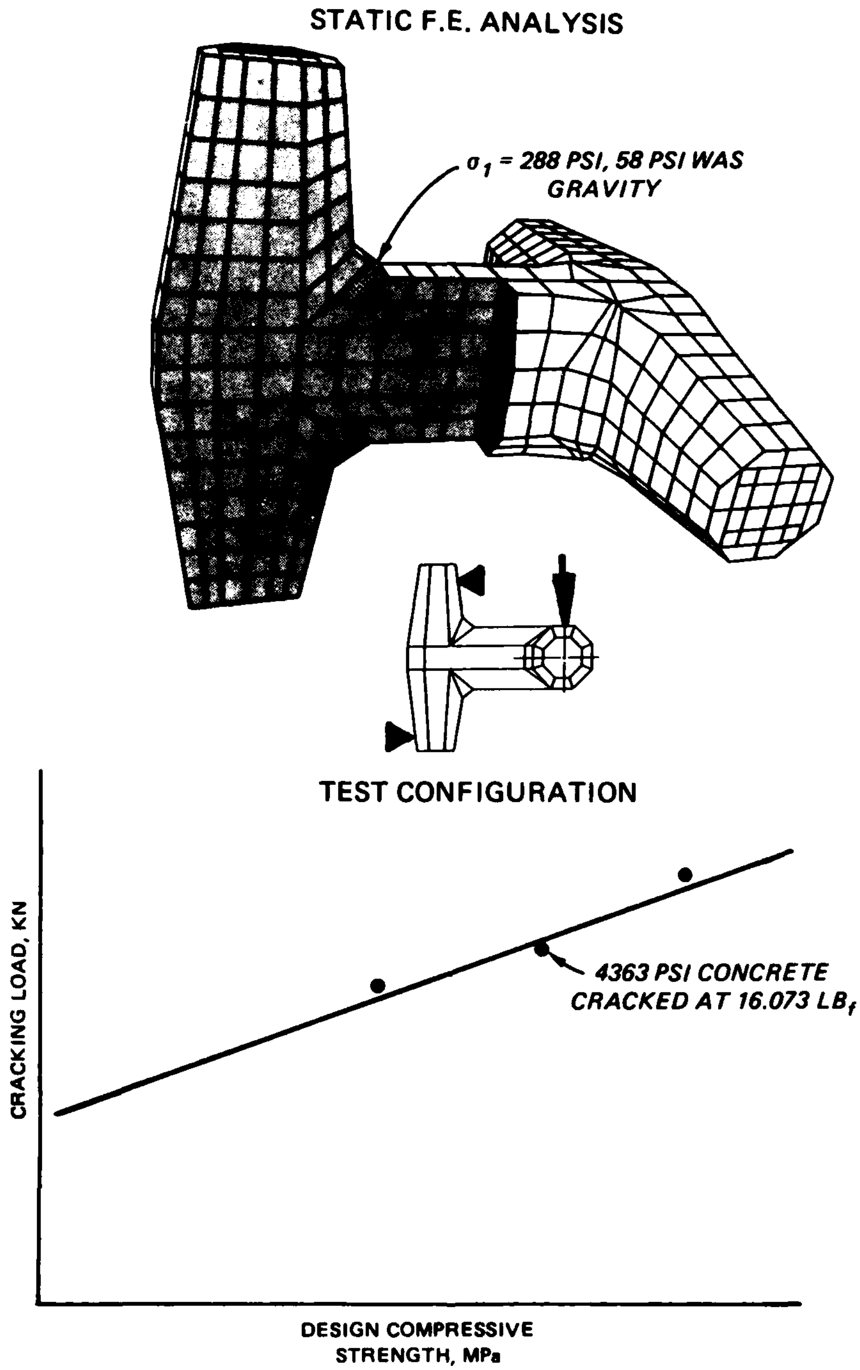


FIGURE 1[illegible]. TERAO, ET AL. STATIC TESTS

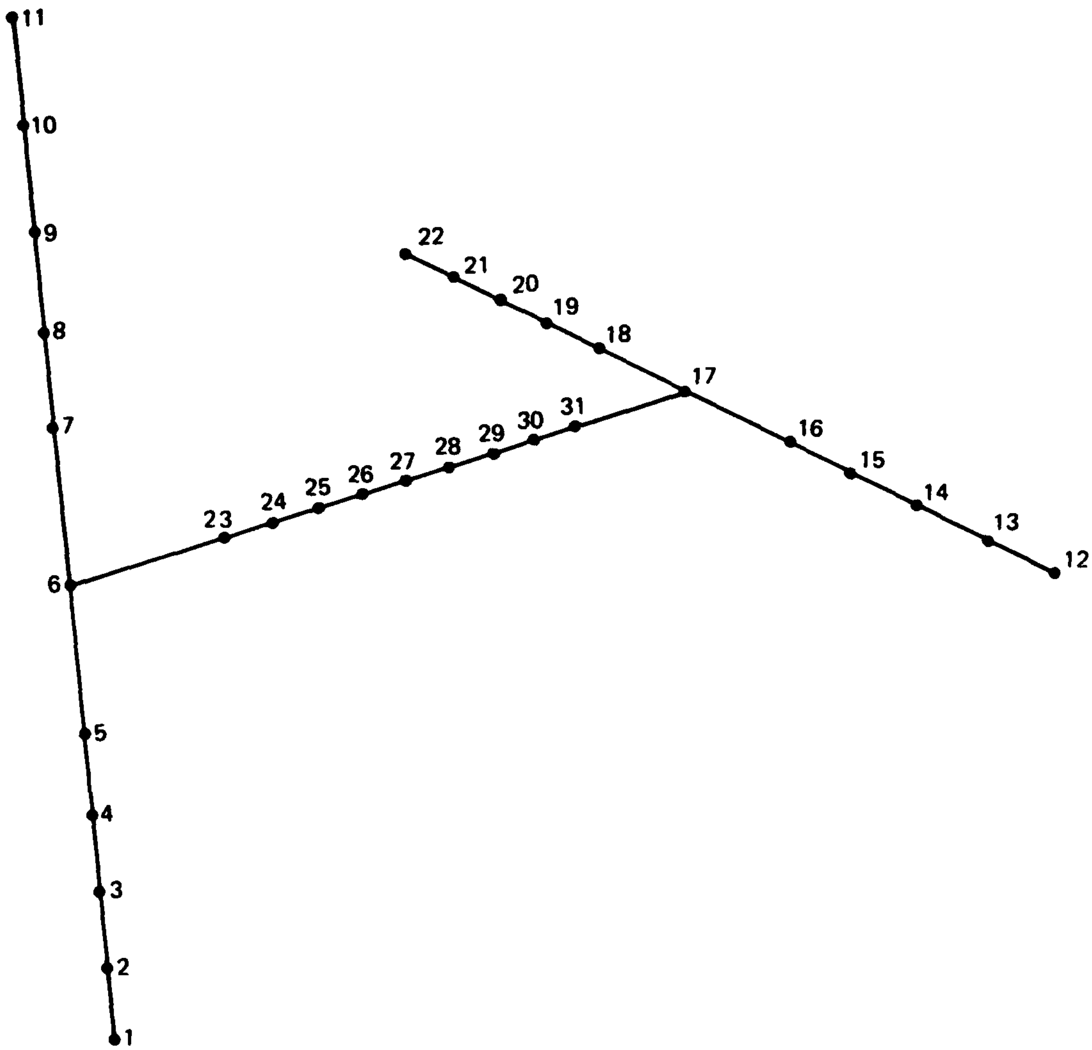


FIGURE 11. BURCHARTH DROP TEST (undeformed grid)

Calibration of the beam grid with Burcharth's drop test is also promising (Figure 12). With this simpler grid stochastic analyses will be undertaken using this beam grid as an analytical model.

Summary

This stochastic approach will depend on input from all phases of the Crescent City Dolos Project. Visual surveys of real and hydraulic models can determine the type and distribution of boundary conditions. Motion pictures of hydraulic models under wave attack can characterize the nature and type of motions that dolosse undergo. Analytical studies of rigid body stability could also add to this knowledge.

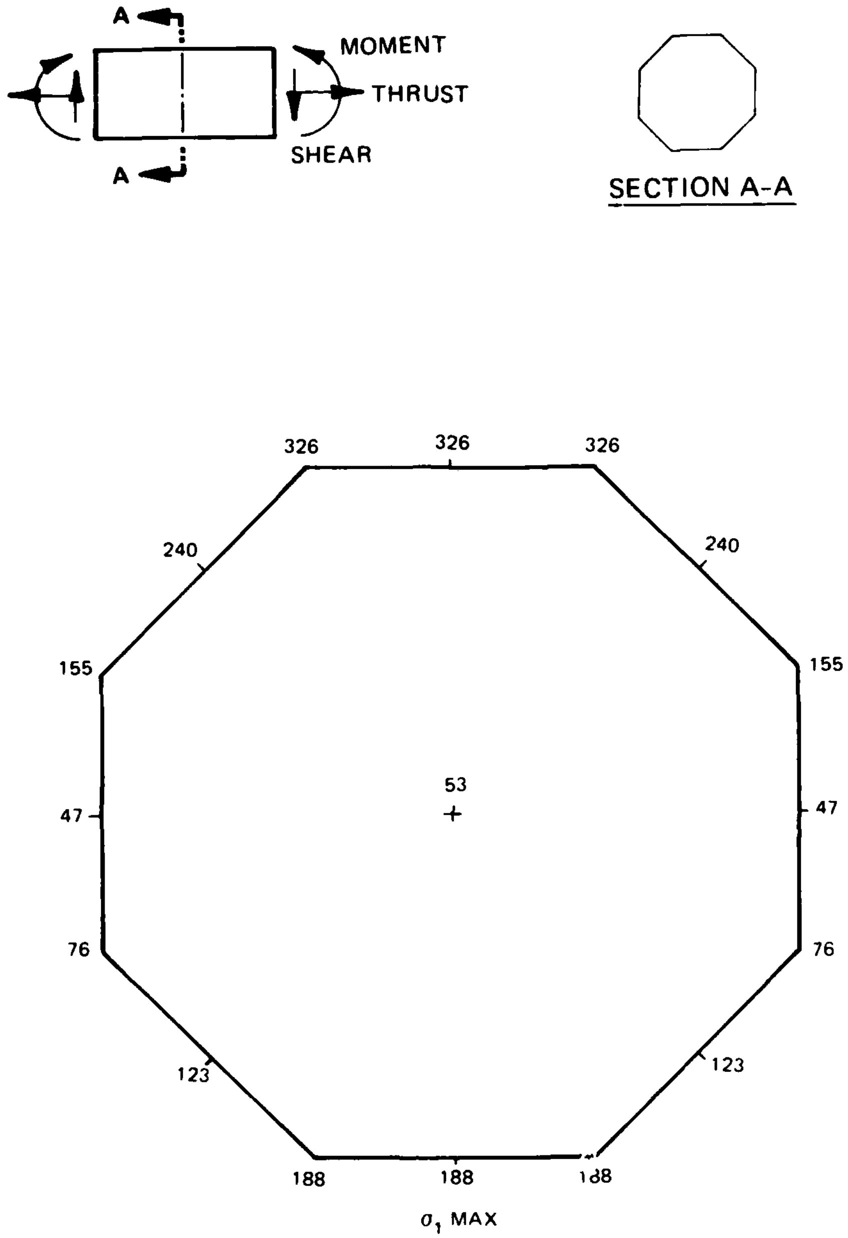


FIGURE 12. DROP TEST, SIMPLE GRID

The prototype measurement program is important because it will provide us with a statistical measurement of response over a cross section of the armor layer as a function of wave environments over a period of time. The information from this program will help validate the stochastic model. As part of the program, an extensive literature search has been made of other research on the structural aspects of breakwater design. The results of the search indicate that much significant work has been performed by the international coastal engineering community. Therefore, following recommendations of the Coastal Engineering Research Board, a workshop composed of Corps engineers, other US coastal engineers, and international engineers and researchers was planned and conducted.

DOLOS WORKSHOP

The Workshop on Measurement and Analysis of Structural Response in Concrete Armor Units was convened by the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi, on 23 and 24 January 1985. This workshop was planned to bring together experts from throughout the world to present papers on and to discuss state-of-the-art understanding of various engineering aspects of concrete armor units. The objectives of the workshop were presented to the participants as four questions:

(1) What design criteria should be used for the structural characteristics of concrete armor units?

(2) What methods hold most promise for use as a design procedure for armor units?

(3) What specific research tools need to be developed in order to focus research on the most practical solution to armor unit design problems?

(4) Should future research emphasize prototype studies, laboratory studies, numerical simulations, or a combination of all three?

Twenty-three scientists and engineers from six foreign countries and the United States were invited to participate in the workshop. This group of distinguished guests, representing academic, Government, and private sector interests, possessed a broad background of knowledge and a diversity of experiences. Case histories from coastal areas around the world were presented and discussed with respect to engineering lessons learned from them.

The workshop was divided into three half-day sessions of invited papers on the following topics: "Prototype Studies of Concrete Armor Units," "Physical Models of Forces on Concrete Armor Units," and "Design Methods and Structural Modeling of Armor Units." The workshop concluded on the afternoon of the second day with a summary, discussion, and recommendation session involving all of the participants.

First Session

The first session, "Prototype Studies of Concrete Armor Units," opened with a paper by Mr. Gary Howell, WES/CERC, on the Crescent City Prototype Dolosse Study. Mr. Howell presented an overview of the Crescent City instrumented dolos design, a series of possible plans for arraying dolosse on the breakwater, and results of recently completed field tests on cable deployment techniques. Mr. Dean Norman, WES/Structures Laboratory, presented a paper titled "The Prototype Study of Thermal Strain in Dolosse" which discussed a study conducted to investigate construction or curing-related cracks which may develop during the construction process. Results from these tests indicated that internal strain during curing is very low, or less than 8 μin./in.

A summary of comments by Dr. Hans Burcharth, University of Aalborg, Denmark, on the Crescent City breakwater study was presented by Mr. Orson Smith, WES/CERC. Dr. Burcharth stressed the point that Crescent City was more than a site-specific study because it has the potential to supply information of general interest for a broad range of engineering applications. He also addressed the need to measure static stresses due to gravity, arching, and wedging and pulsating stresses due to flow forces as well as impact stresses due to impacting bodies. The final paper of this session, "Portuguese Experience--Ongoing Studies," was presented by Dr. Manuel da Silva, Ministerior Da Industria E Energia, Portugal. Dr. da Silva discussed the Sines breakwater failures of 1978 and 1979 with 32-ton dolos units. He then described rehabilitation design for Sines using 88-ton cubes which were tested at small scale in Delft and at full scale using railroad cars to conduct impact collision tests.

Second Session

The second session, "Physical Models of Forces on Concrete Armor Units," began with a paper by Dr. Robert Dean, University of Florida, titled "Modeling and Field Testing of Concrete Armor Units." He stressed the need to model carefully the wave spectrum, direction, and dynamic setup. Dr. Dean also discussed possible modes of breakwater failure from liquefaction to unraveling and concluded by emphasizing the need for quality control in field testing. Mr. Douglas Scott presented a paper for Dr. David Turcke, Queen University, Canada, titled "Measurement of Stress Distributions in Model Dolos Armor Units." This presentation focused on measuring stresses in small, 1- to 3-cm-high dolosse using strain gages placed along their surfaces. Mr. Scott discussed general results from both static and dynamic loading tests.

Dr. Hans Ligteringen, PRC Harris Engineering, Inc., The Netherlands, presented a paper titled "Structural Strength of Armor Units, Implications for Design and Construction." Dr. Ligteringen stated that many great failure cases such as Sines, Tripoli, and San Ciprian were caused by dolos or tetrapod damage. He concluded that cubes can be cast at greater weights than dolosse or tetrapods and yet maintain a compatible structural strength. He also concluded that cubes have a higher breaking impact velocity than dolosse or tetrapods. Mr. Hiejdra, Delft Hydraulics Laboratory, The Netherlands, next presented a paper titled "Movement and Design Forces for Breakwater Armor Units: Determination and Prediction by Scale Models." Dr. Hiejdra discussed measurement of both hydraulic and rocking damage to model breakwaters and their armor units using a wide variety of still and movie photographic techniques. He also showed results from application of some of these photographic techniques in the prototype. He emphasized results using alternate positive-negative photographs and constructing overlays from them.

The final speaker for this session was Dr. Cyril Galvin, consulting engineer, who presented some comments on breakwaters and breaking waves. Dr. Galvin stated that critical breaking wave heights could be identified above which concrete armor units would break. For 3,000-psi concrete, waves could not exceed 14 ft; and for 6,000-psi concrete, they could not exceed 20 ft. His argument was based on the idea that at points of contact between armor units high compressive stress was exerted owing to the impact wave force being concentrated through a small contact area.

Third Session

The third session, "Design Methods and Structural Modeling of Armor Units," began with general remarks on "Stresses in the Dolos" by Mr. Omar Lillevang, consulting engineer. Mr. Lillevang first described a series of experiments using surface coatings and photoelastic determinations to determine three-dimensional stress distribution on a dolos. He then enumerated a series of concerns he had for the Crescent City prototype test and provided some constructive suggestions for additional tests which might be carried out in association with the planned prototype measurements.

Dr. J. A. Zwamborn, National Research Institute for Oceanology, South Africa, presented a paper titled "Behavior of Dolos Structures--Especially Regarding Unit Strength." He showed numerous photographic and underwater survey data from dolos structures throughout South Africa and other worldwide locations. His concern focused on mapping movement to assess hydraulic stability and unit damage related to incident wave height conditions. Dr. Zwamborn then presented some criteria, to be applied in design, which ranged from no movement/no breakage to an optimum design which would allow rocking movement and would reinforce dolosse to be strong enough to withstand these limited movements. Dr. Zwamborn concluded his talk with a discussion of a variety of reinforcing techniques for dolosse.

Dr. Taiji Endo, Nippon Tetrapod Company, Japan, presented a paper titled "Outline of Our Studies on Problems of Structural Strength of Armor Units" detailing his large-scale model studies on mechanical strength and dynamic stress in dolosse and tetrapods. He pointed out that in both static load and drop tests stress was greatest in the corner between the chamfer and the shank. Therefore, reinforcement of the chamfer should reduce the magnitude of stress concentration. Dr. Endo also discussed a series of tests using strength-reduced materials designed to provide information on physical properties of concrete material under stress. Dr. Osamu Kiyomiya, Port and Harbor Research Institute, Japan, discussed "Structural Analysis of Armor Concrete Members to Dissipate Wave Forces." He showed a new type of breakwater called an arch shaped slit caisson which is intended for placement in 10 to 15 m of water. The structure is designed to dissipate wave forces and to reduce cost related to use of large numbers of concrete armor units. Dr. Kiyomiya showed load tests, finite element analysis, and field observations of the breakwater.

Drs. William McDougal, Oregon State University, and Joseph Tedesco, Auburn University, made a joint presentation titled "Nonlinear Finite Element Model Analysis of Concrete Armor Units." Their work is directed at modeling slamming forces on a dolos unit in a simplest case where the flukes are approximately a horizontal cylinder, and waves are approaching straight on. They use a time-dependent slamming force with a very rapid rise time to initially force the system and a drag equation to express the submerged drag dominated regime which follows initial wave impact. Dr. Tedesco discussed structural analysis results from their nonlinear finite element model subjected to slamming forces. The main feature of the material model is that it correlates nonlinear stress-strain relationships, including strain softening, with increasing compressive stresses. The model also includes a failure envelope that defines cracking, crushing, and compression. Final results from their modeling provided a relationship between failure of a dolos unit and wave impact conditions on the dolos. They concluded that, for smaller dolosse, structural stability had to be increased relative to hydrodynamic stability.

The final presentation by Mr. Robert Cole, WES/Structures Laboratory, was titled "Structural Aspects of Dolos--A Finite Element Model Approach." Mr. Cole addressed the problem of providing information on torque, moment, shear, and thrust distribution through the shank and the fluke of a dolos. This information would in turn be used to determine unit strength versus cost of reinforcing for optimizing these two concerns in design.

Final Session

In the final afternoon session of this workshop a set of recommendations was developed for the Crescent City Prototype Dolosse Study. These recommendations were as follows:

(1) To define the incident wave conditions completely.

(2) To obtain excellent bathymetry near the structure.

(3) To maintain good photographic records of the dolos prototype tests.

(4) To evaluate impact, pulsating, and static stresses in the dolos armor units.

(5) To perform drop tests to destruction on instrumented and non-instrumented dolosse.

Consensus of the participants was that the instrumented dolos design was good and need not be modified. A number of suggestions was put forward on measurement of incident wave conditions as well as internal measurement of pressure and flow velocity around the units. There was an overall enthusiasm for this study, and many participants expressed interest in continued involvement with the results from this experimental program.

CONCLUSION

The Crescent City Dolos Study has completed the program definition and design phase. Progress has been made in gaining a better understanding of the problem, defining an approach to interpreting the data, implementation of the finite element models, and design and evaluation of the instrumentation systems. Consultation and coordination with international researchers has benefited the program and will provide the basis for more effective use of the data, once acquired. Successful execution of the program will result in a design methodology which will allow Corps designers to predict the structural strength requirements for dolos concrete armor units and therefore result in substantial savings in the rehabilitation costs of Corps dolos structures.

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DISCUSSION

PROF. WIEGEL: *At some place in the structure failure is going to occur. We're interested in why it fails. How do you determine where and how it fails during that portion when it fails?*

This looks like more of an elastic analysis.

MR. COLE: That's why we have the comparison with a calibration test like the drop test. When we see stresses or moments of a certain value, we expect the thing to fail.

PROF. WIEGEL: *Am I right? Is this an elastic analysis?*

MR. COLE: Yes.

PROF. WIEGEL: That's what I thought. Okay. I wanted to be sure I hadn't missed something.

MR. COLE: It's elastic analysis.

PROF. WIEGEL: You have married this to other things because there are other ones that I've seen for earthquake loads using elastic analysis.

MR. COLE: Well, you know, we have a very difficult time doing dams. You design a dam for an earthquake--which you hope never happens--and have great difficulty in modeling the properties of the dam not knowing how the dam is going to behave. This is much like the dolos. We have seen repetitive loadings--perhaps day-to-day or week-to-week and certainly from storm-to-storm. You don't even want to get out the linear range; you'd rather stay quite linear. But the point I want to make is not a deterministic problem, I don't think. It has to be looked at from a stochastic sense. There's not one condition which is the worse you design to and hope the thing survives. Prototype data will provide a sample of the data base for us. It will show us those things that the distribution of these loads and responses will expect to get out of it.

MR. HOWELL: This part of the talk is one that started the current state of progress in the field measurement and the prototype measurement--the instrumentation part of the prototype dolos study. We gave a description of the program at the Seattle CERB meeting to members of the Board, and we also had a special meeting of the civilian CERB members at Crescent City in August of last year. What I would like to do at this CERB meeting is to describe some of the progress we've made in preparing for the prototype study and in particular concentrate on the three aspects. We have been very busily engaged in quite a bit of effort, some of it relatively routine and mundane, others of it a little more challenging. We will measure hydrodynamic pressures within the breakwater, stress due to wave induced impacts, as well as the static and the pulsating stresses. We will combine our results with the work of finite element modeling. And the result of all this work we hope to be a structural design procedure for the districts which will allow the necessary structural strength for a given breakwater dolos design to be predicted in advance.

All of us would be happy to take questions if there is still time left.

PROF. WIEGEL: *I forgot one other aspect, and that is once you collect these data up at the breakwater, how are you going to get them into the lab?*

MR. HOWELL: Okay. The data will be acquired at a shorebased computer facility located in a trailer set back from the breakwater. It will be at the Crescent City site, but it will be cabled back to the trailer. Everything from here up is within the dolos. We have digital data coming out of the dolos. The data from each dolos will go into what we call concentrators which will actually be located on the cap. Then there are two cables, one from each of two concentrators for redundancy which will come back to a shorebased minicomputer system, and that's where the data will be acquired. The data quantities are such that they must go on to mag tape, in fact, quite a bit of mag tape.

MR. McCLEESE: *You have tested the cables, now how about the strain gages?*

MR. HOWELL: Yes, the strain gages have been tested. We have made ourselves the beneficiaries of the long years of experience of the Instrumentation Services Division at the Waterways Experiment Station. They have been putting in strain gages using very similar technology in the locks and dams for years. We have added another whole suite of rigorous testing, due to the saltwater environment, and we've taken their technology and added about two or three levels of waterproofing to the instrumentation. Our testing has proven that in order for water to get to the strain gages, it would have to get through two or three barriers that we've added to the instrumentation.

PROF. WIEGEL: *Again, you concentrated on this one portion. Now, there's another part of getting data and it is a check on instrumentation because if you got the solid body accelerometers, you're going to do a double integration to get motions. And sometimes things go wrong. What was the photographic thing or are you going to use video with zoom lenses?*

MR. HOWELL: Right, we're going to try to do as much photographic work as we can. That was one of the strongest recommendations from the workshop. And our problem there is finding the proper shore site. There isn't any one obvious good site, and we're trying to find the best site now to get that photographed. We have a helicopter on contract, so we'll go in and get routine things. We also like to get a sort of continuous type of stop action photography.

PROF. WIEGEL: *I have been working with a company for many years on a coastal located power plant, and one of the requirements there, by one of the regulatory commissions, was what they call a meterological tower—met tower—which is quite high. On it they have a camera with all automatic sensing and so forth. These things are designed to do work, and you do get the elevation that you need with the present sort of sensing devices. You can have the lighting automatically compensated for. Have you considered the use of one of these meterological towers?*

MR. HOWELL: *On the cap itself or somewhere on shore?*

PROF, WIEGEL: Well wherever one may have to be put, but I mean in order to get the elevation.

MR. HOWELL: We considered putting it on the cap, but we haven't figured out a way that we could put a structure out there cheaply enough that would withstand the wave forces that we have. We have been looking at sites set back from shore, and I'm fairly confident we're going to be able to do something. What we would like is a site that is sort of adjacent to the breakwater because of the way the breakwater is set up. There's a little rock here, but it doesn't really have a good angle, and then the shore kind of goes back. We're going to figure that out; we just haven't solved that problem yet.

Somehow that's going to be done. I just can't tell you how we're going to do it yet.

MR. KENDALL: *For Bob Cole. You mentioned failure stress that would come from the drop test, and then I saw a question about fatigue. Isn't that probably your most failure?*

MR. COLE: I think that some of the prototype data will tell us. We see indications of breathing day after day even in moderate conditions, and then fatigue could be a factor. If it's fairly quiet, you only see major responses on major storms that go on in and around the ocean. But I think that's one of the things to point out to us.

MR. KENDALL: So you will adapt.

MR. HOWELL: I think the answer to that is we just don't know. If we knew the answer to that we probably wouldn't need the study. We're just trying to be prepared for any mode of failure.

COASTAL ENGINEERING RESEARCH CENTER
FIELD TRIP

INTRODUCTION

The Coastal Engineering Research Center (CERC) is the Nation's foremost research and development laboratory for coastal engineering. CERC was relocated from Ft. Belvoir, Virginia, in 1983 to form the fifth major laboratory at the US Army Engineer Waterways Experiment Station (WES). The combination of unique experimental and field research facilities and a staff with broad expertise in physical modeling, experimental studies, numerical modeling, and prototype/field measurements provides a comprehensive approach to the solution of the diverse and complex problems of the coastal zone.

Research at CERC is designed to provide a better understanding of waves, winds, water levels, tides, currents, and the resultant coastal processes. Equally important are the interactions of these forces and processes with shores, beaches, inlets, inner continental shelves, and coastal and offshore structures. Research efforts focus on specific problems in shore and beach erosion control; coastal flood and storm protection; sand bypassing, dredging, navigation improvement, and harbor design and improvement.

CERC's present physical modeling facilities (due to the combination of equipment from Ft. Belvoir with that at WES) are among the most modern and efficient in the world. These facilities consist of seven three-dimensional test basins totaling over 280,000 sq ft (approximately 6.5 acres). The basins are equipped with ten regular wave generators (total length 675 ft), two spectral wave generators (total length 300 ft), one directional spectral wave generator (total length 90 ft), five tide generators, and five steady-state circulation systems. In addition, there are ten wave flumes, ranging in width from 1 to 50 ft, with a total length of over 1,700 ft. Six of the flumes have spectral wave generators, and four have regular wave generators. Also, there are two automated data acquisition and control systems (consisting of computers, peripheral equipment, and model sensors) for acquisition and processing of model data. Various model equipment includes cameras, instrumentation, wave absorbers and filters, radio-controlled ships, and movable-bed materials.

In addition to the tour itinerary, this section includes information and photographs of the sites visited.

43RD COASTAL ENGINEERING RESEARCH BOARD MEETING

BUS TRIP ITINERARY

23 May 1985

TOUR OF CERC'S EXPERIMENTAL FACILITIES

8:00 Leave Hotel Enroute to WES

8:15 - 8:40	San Pedro Breakwater Rehabilitation
8:40 - 9:05	Cleveland Harbor Breakwater Rehabilitation
9:05 - 9:30	Lake Pontchartrain Outfall Canal Study
9:30 - 10:00	Mission Bay Breakwater Revision
10:00 - 10:30	Coffee break at CERC headquarters building
10:30 - 11:45	Los Angeles-Long Beach Harbors Model

11-ft Flume - Low Crested Breakwater Studies
6-ft Flume - Breakwater Stability Studies
Fisherman's Wharf Model
Data Acquisition and Control Facility
Noyo Harbor Model
Directional Spectral Wave Generator
3-ft Flume - Wave Runup and Overtopping Study
1.5-ft Flume - Lab and Scale Effect in Movable Bed Modeling

11:45 - 12:20	Coastal Field Data Collection Facility
12:20 - 12:30	Bus transportation to Best Western Hotel

SAN PEDRO BREAKWATER REPAIR STUDY

The San Pedro breakwater performed its intended function for a number of years with minimal maintenance. However, during the winter of 1982-1983 the structure was subjected to severe wave attack in concert with exceptionally high still-water levels, and extensive damage was incurred. Model tests were conducted at WES during June to September 1983. Based on results of these tests, a molded concrete block repair section and a stone rubble-mound repair section that are more stable than the laid-up granite block section of the existing breakwater were developed. The stone rubble-mound repair option was chosen for use in the prototype. However, due to time constraints, the repair section actually constructed differed significantly from the section developed in the original model study. The purpose of the present investigation is to determine stability of the repair section as constructed in the prototype and to develop alternate plans if needed.

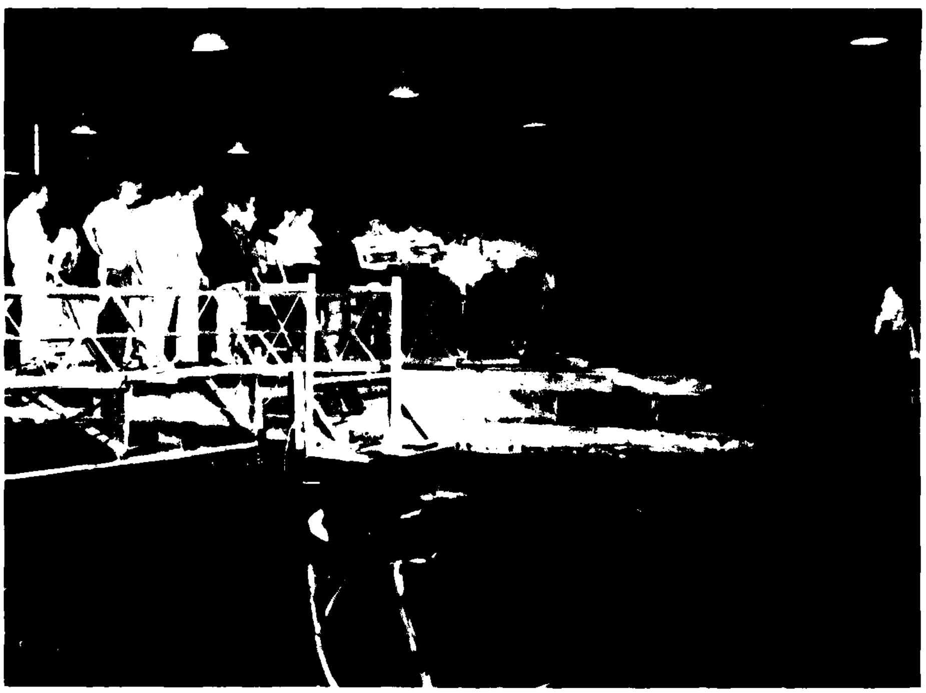

PHOTO 1

SAN PEDRO BREAKWATER REPAIR STUDY

PHOTO 2

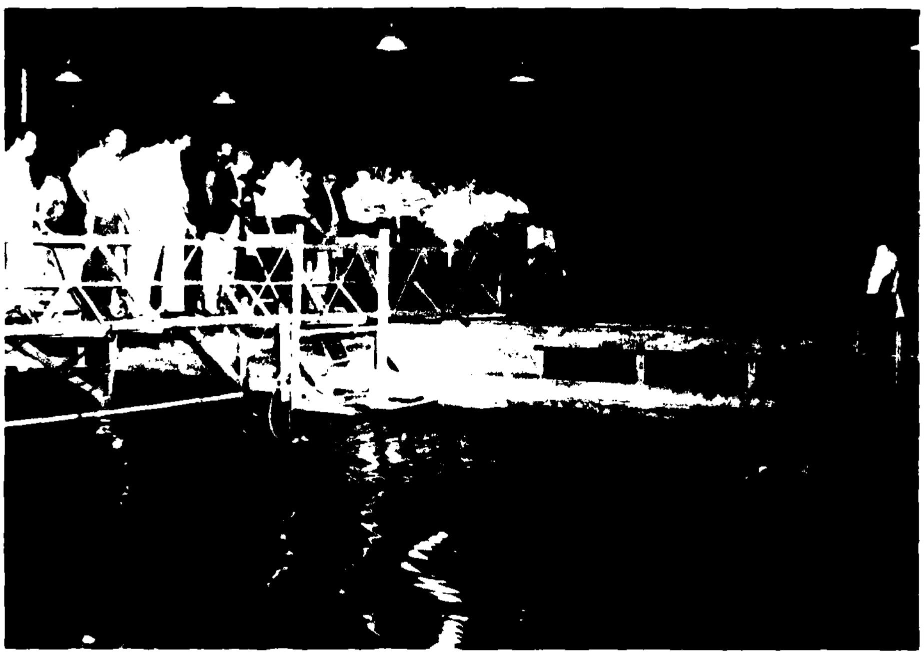

PHOTO 3

SAN PEDRO BREAKWATER REPAIR STUDY

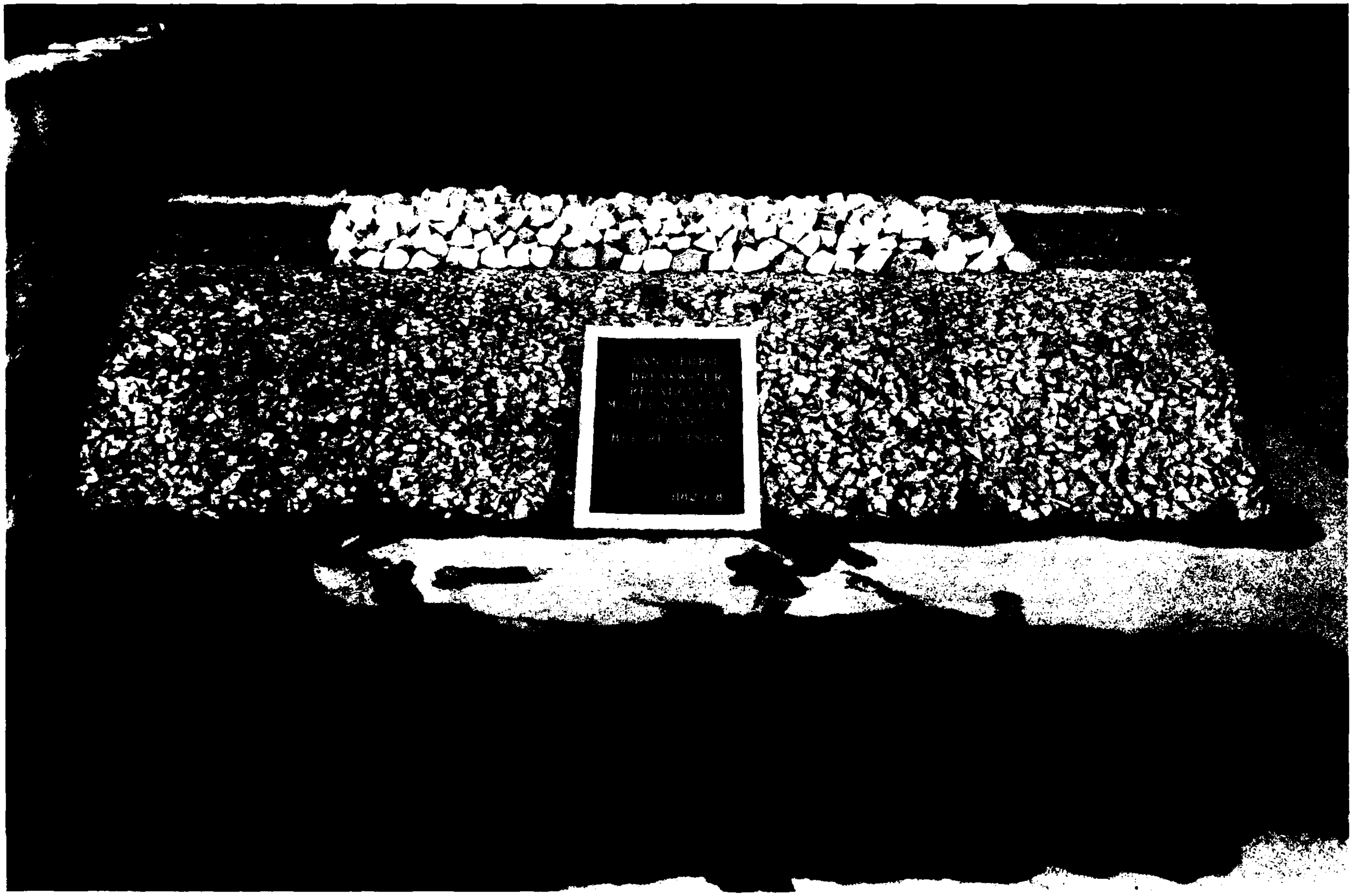

PHOTO 4

SAN PEDRO BREAKWATER REPAIR STUDY

WAVE STABILITY TESTS OF PROPOSED DOLOS AND ARMOR STONE REHABILITATION DESIGN ALTERNATIVES FOR THE EAST BREAKWATER AT CLEVELAND HARBOR, OHIO

Two-dimensional breakwater stability tests are being conducted to determine the no-damage design wave heights for two proposed rehabilitation designs and one existing 2-ton dolos design for the lakeside trunk of the east breakwater at Cleveland Harbor. The rehabilitation designs consist of 4-ton dolosse and graded, 9- to 20-ton, armor stone. Results to date have shown that the 2- and 4-ton dolosse are stable for 10.5- and 12.0-ft nonbreaking, overtopping waves, respectively (for wave periods of 7, 8, and 9 sec at a still-water level of +4.9 ft low water datum). Testing of the 9- to 20-ton armor stone section is ongoing at the present time.

PHOTO 1

CLEVELAND HARBOR BREAKWATER MODEL

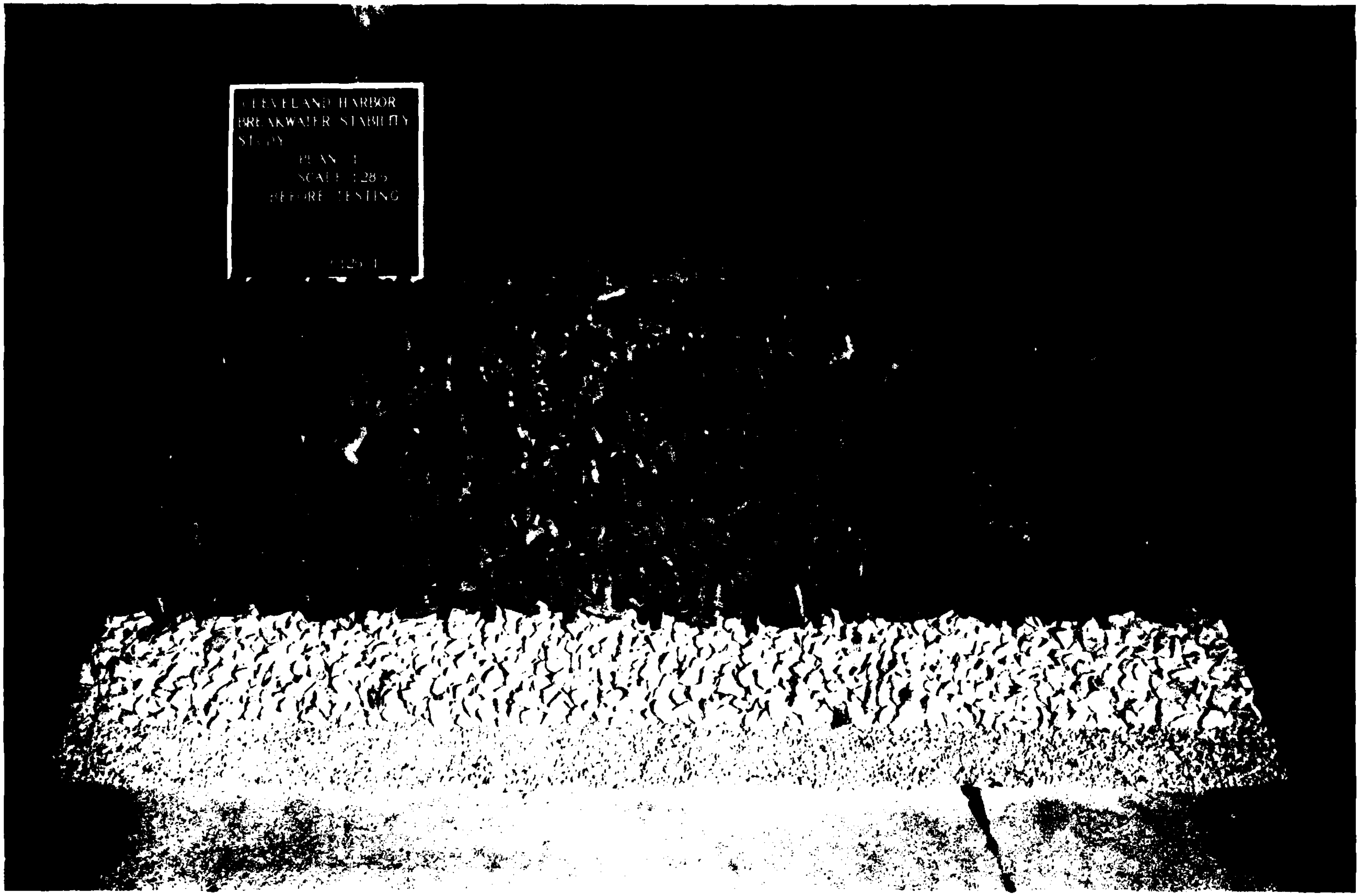

PHOTO 2

LAKESIDE VIEW OF 4-TON DOLOS DESIGN AT CLEVELAND HARBOR

MODEL STUDIES OF LAKE PONTCHARTRAIN OUTFALL CANAL

A 1:20-scale physical model of a portion of Lake Pontchartrain and the London Avenue Canal is being used to determine the optimum location and effectiveness of a proposed multigated structure with butterfly control valves to prevent flooding of New Orleans by hurricane surges from Lake Pontchartrain. The model simulates wave action from Lake Pontchartrain and discharges from the city's pumping stations. The performance of vertically pinned butterfly gates during simulated hurricane surges from Lake Pontchartrain and during pumping from New Orleans to the Lake are being investigated for various gate designs and operating conditions. Other factors being considered include potential for reverse flow through some of the gates and possibly structural realignment to improve hydraulic characteristics.

PHOTO 1

LAKE PONTCHARTRAIN OUTFALL CANAL MODEL

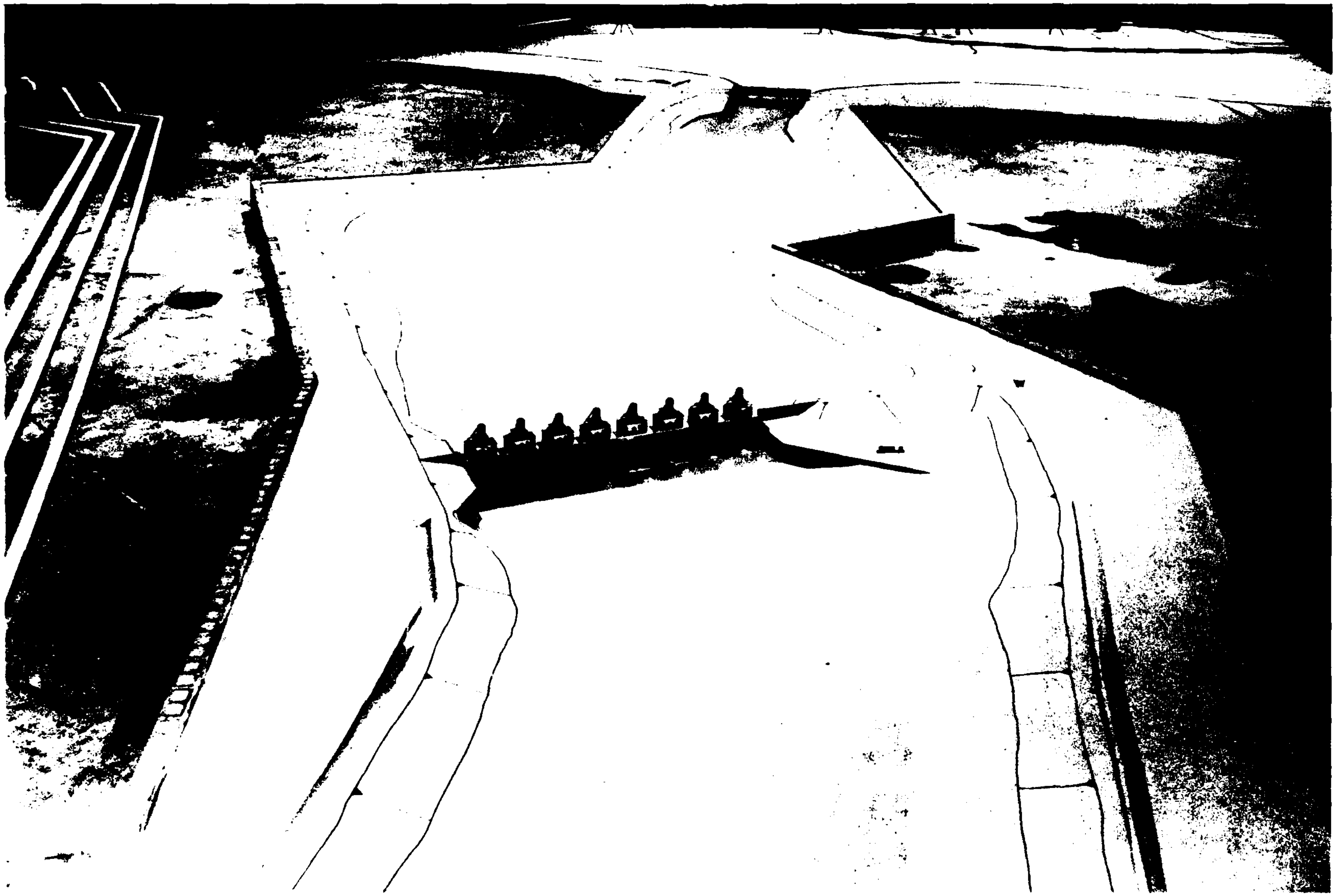

PHOTO 2

GENERAL VIEW OF 1:20-SCALE MODEL OF LAKE PONTCHARTRAIN OUTFALL CANAL

MODEL STUDIES OF MISSION BAY HARBOR
SAN DIEGO COUNTY, CALIFORNIA

Mission Bay is located on the coast of southern California about 10 miles north of the entrance to San Diego Bay. The complex covers an area of approximately 4,000 acres and is very popular for recreational purposes. The San Diego River empties into the Pacific Ocean immediately south of Mission Bay. The existing Federal construction project in Mission Bay and San Diego River was completed in 1959. The entrance to the bay is protected by a 3,300-ft-long north jetty and a 4,270-ft-long middle jetty. The middle jetty also serves to separate the navigation channel from the San Diego River flood-control channel. A 2,050-ft-long south jetty forms the southern border to the San Diego River. Mission Bay is a small-boat harbor as well as an aquatic park providing a wide range of public and private water-oriented recreational facilities.

Hazardous wave conditions exist in the harbor entrance channel during storms, and these waves have resulted in vessels sinking, with resultant loss of lives. Excessive surge conditions in the boat basins (Quivira Basin and Mariners Basin) cause damage to boats and facilities inside the harbor. Numerous cracked and sinking floats, broken pilings, worn piling collars, split timbers, and frayed and broken mooring lines can be observed. Water lines and electrical conduits break periodically, resulting in service disruptions and large utility bills and repair costs. As a result of littoral transport and flooding, a sand plug has developed at the mouth of the San Diego River. The sand plug serves as a beach area and is used extensively for beach recreation. Removal of the sand plug would incur extensive outcries from the public and would not be accepted. However, the sand plug substantially reduces the channel capacity and creates a hazardous flood situation. It is estimated that a standard project flood would result in damages upstream exceeding $5,000,000.

The Mission Bay model was originally constructed in 1978 to investigate:

(1) Hazardous conditions at the entrance to the harbor due to large short-period (7- to 20-sec) waves.

(2) Surge due to long-period (30- to 140-sec) waves causing damage to boats and facilities inside the harbor.

(3) Potential flood hazards due to a sand plug at the mouth of the San Diego River flood-control channel.

Results of these tests indicated that a 1,600-ft-long rubble-mound breakwater installed 525 ft offshore with the concurrent removal of 230 ft from the seaward end of the north jetty would provide safe entrance conditions and reduce surge inside the boat basins. A 1,200-ft-long weir (elevation +6 ft) in the middle jetty was required to permit excess San Diego River flows to escape into Mission Bay and minimize flooding upstream.

At the request of the US Army Engineer District, Los Angeles (SPL), the Mission Bay model has been reactivated by WES to evaluate additional alternative plans at the harbor entrance. The purpose of this investigation is to determine the optimum breakwater configuration at the entrance with respect to wave and surge protection and construction costs while providing minimal interference to surfing conditions adjacent to the jetties.

PHOTO 1

MISSION BAY MODEL

PHOTO 2

PHOTO 3

MISSION BAY MODEL

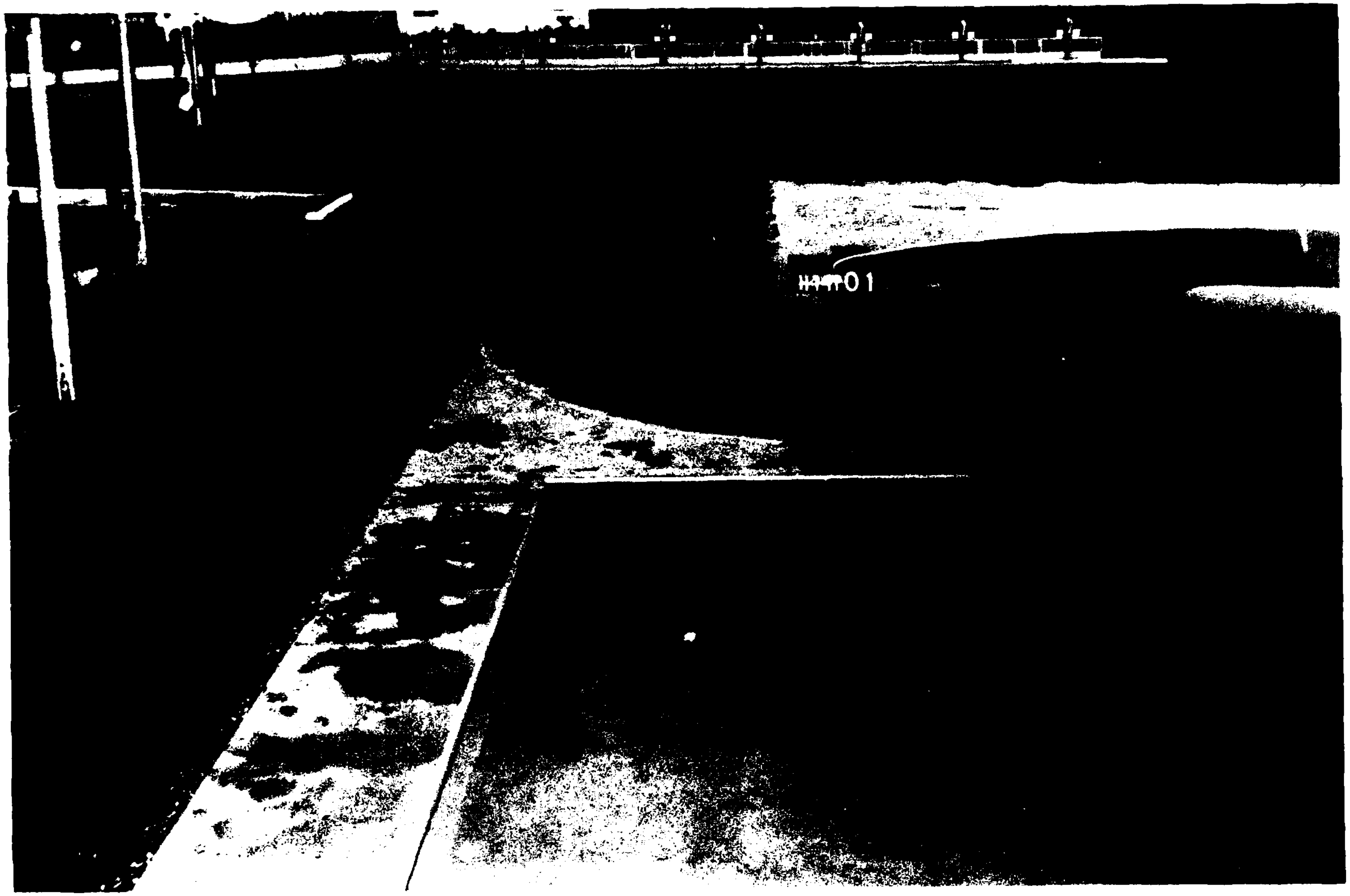

PHOTO 4

GENERAL VIEW OF 1:100-SCALE MODEL OF MISSION BAY HARBOR

MODEL STUDY OF LOS ANGELES AND LONG BEACH HARBORS, CALIFORNIA

The Los Angeles and Long Beach Port Authorities plan to construct additional harbor basins and dredge deeper channels and harbor areas because of the anticipated future need for additional ship-mooring facilities. Insofar as is practical, it is desired to ensure satisfactory mooring conditions with respect to wave and current conditions and their effects on ship surge. It also is desired to determine whether the proposed construction plans will increase wave and surge action conditions in the existing harbor areas and whether tidal flushing of the harbor areas will be adversely affected by the proposed extensive expansion of existing docking facilities. By direction of the Chief of Engineers, a model study is being conducted by WES's Coastal Engineering Research Center (CERC). The objectives of the Los Angeles-Long Beach Harbors study are to:

(1) Determine the incidence and severity of troublesome oscillations in the present harbor complex.

(2) Investigate tidal circulation characteristics of the present and future harbors.

(3) Determine the optimum plan of future expansions for providing safe and economical berthing areas.

(4) Analyze the effect of future expansions on the existing harbors.

To achieve the stated objectives, the following tasks are being undertaken:

(1) Acquiring prototype wave data.

(2) Obtaining observations of ship motion.

(3) Cataloging ships using Los Angeles and Long Beach Harbors.

(4) Conducting analytical investigations of moored ship response.

(5) Performing extensive analyses of prototype wave data.

(6) Attempting to correlate ship motion with wave height and frequency.

(7) Collecting prototype data for verification of model tests of tidal circulation characteristics.

(8) Designing and constructing a hydraulic model.

(9) Conducting model tests of the tidal circulation for the present harbors and planned construction stages.

(10) Conducting model tests of the response characteristics of the existing harbors to long-period wave energy.

(11) Conducting model tests of the response characteristics for construction plans and future improvements to long-period wave energy.

Currently work is under way using the most recent technology to provide a major improvement in our ability to quantify environmental impacts (on circulation, flushing, residence times, etc.) of proposed harbor developments and the capability to quantify estimates of downtime for cargo handling as a function of berthing location, type of ship, and type of mooring. The knowledge to be gained by embarking on this comprehensive study program not only will enhance our understanding of the circulation and flushing characteristics of the present harbors but also will vastly improve our ability to estimate, with confidence, the effects of various long-range plans on the circulation, flushing, and water-quality aspects of the harbors. The additional prototype data on circulation and flushing will enable confidence limits to be placed on predictions of the effect of proposed improvement plans on circulation and flushing characteristics of the harbor's complex. The harbor response and ship motion program will provide direct, quantitative, and reliable estimates of the percent of downtime at any berthing area within the harbor's complex as a function of type of ship, type of mooring, and type of cargo handling equipment (i.e., allowable motion). All of the above are consistent with the objectives of the model study as originally conceived, planned, and authorized (i.e., the statement that "...The Chief of Engineers shall make such hydraulic model studies as may be warranted...in order to provide for the optimum development of the Los Angeles-Long Beach Harbor Projects" would certainly include upgrading the accuracy and capabilities of the model or models as scientific advances are made).

PHOTO 1

PHOTO 2

LOS ANGELES-LONG BEACH HARBORS MODEL

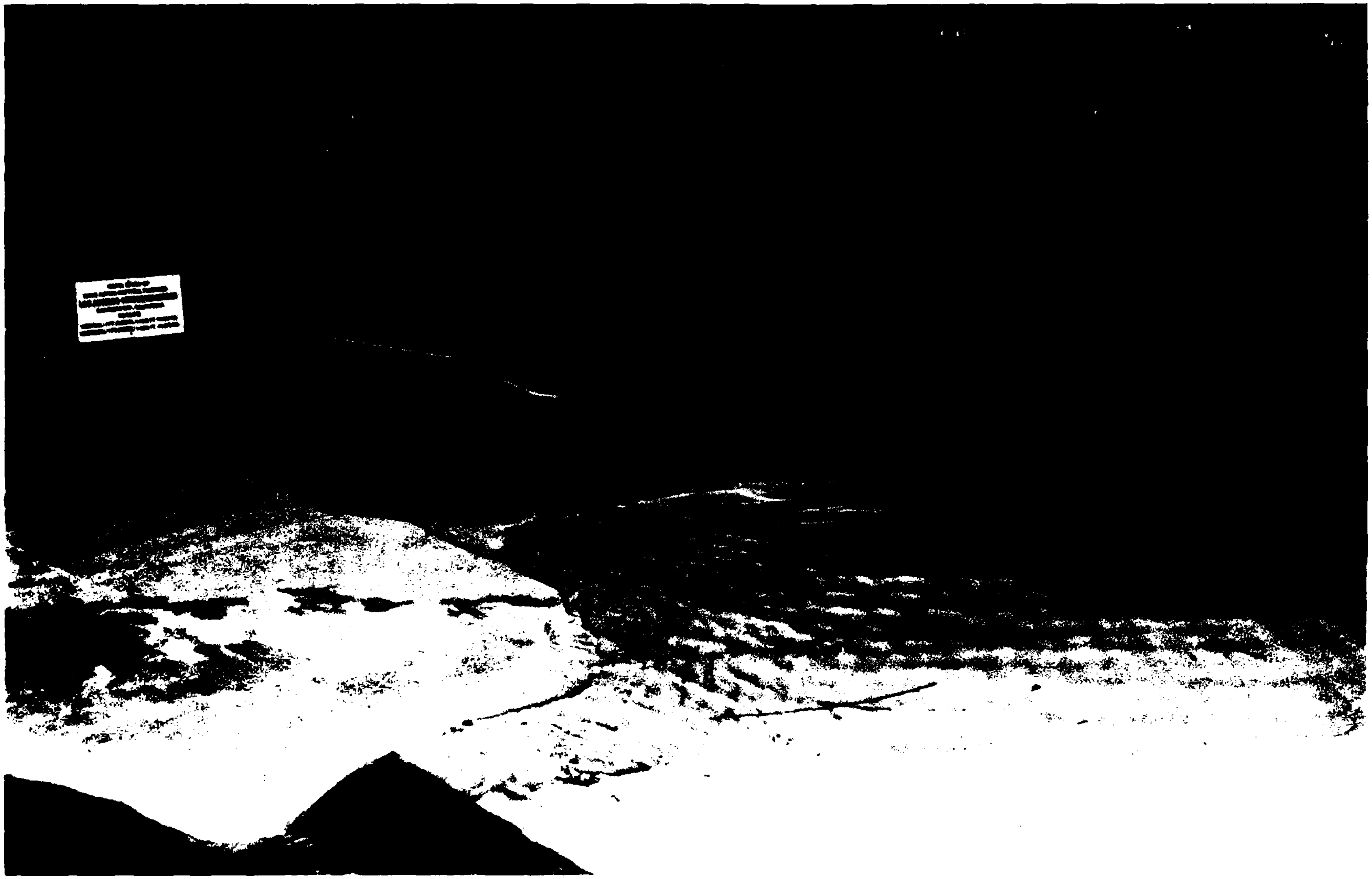

PHOTO 3

GENERAL VIEW OF LOS ANGELES-LONG BEACH HARBORS MODEL
(scales 1:100 vertical, 1:400 horizontal)

LOW-CRESTED BREAKWATER STUDIES IN 11-FT-WIDE SPECTRAL WAVE TANK

A shoaling slope, test platform, and training walls have been installed at the wave absorber end of the 11-ft-wide wave tank. The shoaling slope and platform will allow waves to be generated in water depths greater than those at the side of the test structure. This type of setup will ensure that very severe incident wave conditions can be obtained at the structure if they are required. Testing will normally be conducted within one of the channels formed by the training walls allowing a significant portion of the tank width to be used as a wave absorber. This configuration is necessary to reduce the influence of wave reflection from the structure when conducting tests of long duration with wave spectra. The first series of tests in this wave tank are to determine the stability, wave transmission, and wave reflection characteristics of low-crested rubble-mound structures subject to irregular wave attack. These tests are a continuation of a test series initiated when CERC was at Ft. Belvoir.

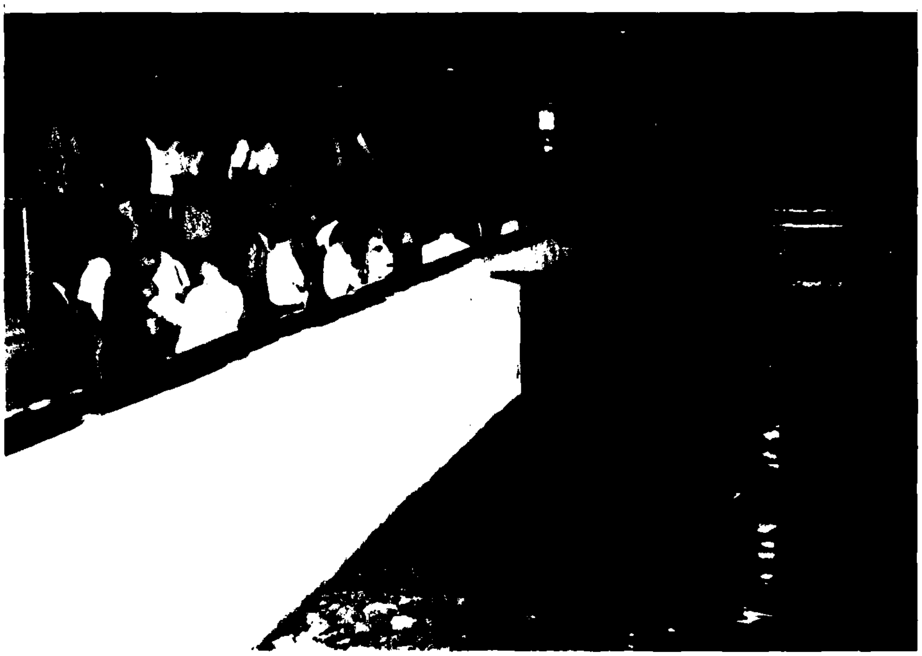

PHOTO 1

LOW-CRESTED BREAKWATER STUDIES

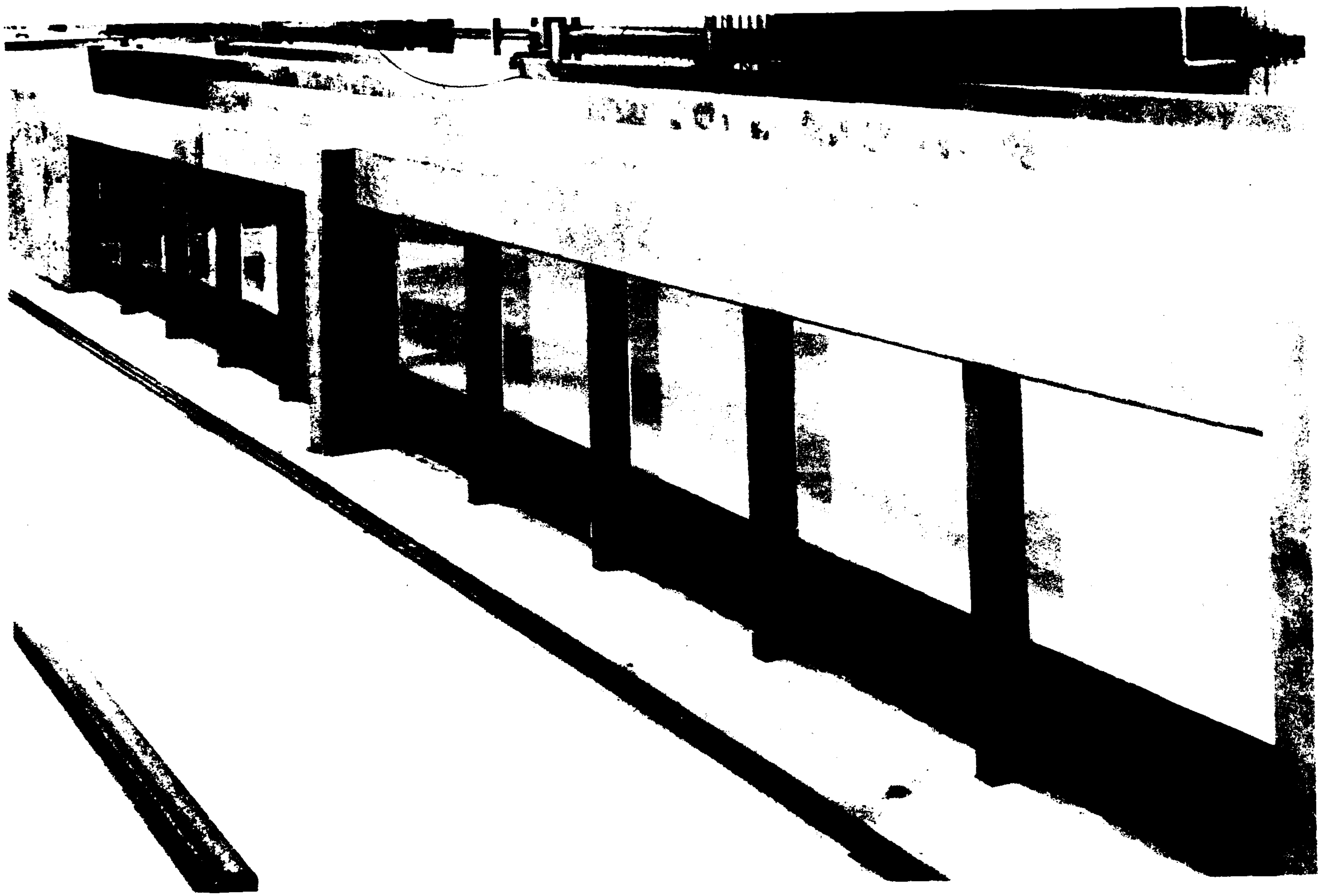

PHOTO 2

GENERAL VIEW OF 11-FT-WIDE SPECTRAL WAVE FLUME

BREAKWATER STABILITY STUDIES IN CERC'S 6-FT SPECTRAL WAVE FLUME

The objective of this investigation is to develop design criteria supported by experimental data from which the planning and design of safe and economical rubble-mound breakwaters can be determined. The approach is to experimentally study the stability of both trunk and head sections for various wave conditions using both natural stone and concrete armor units. The present effort addresses stability of stone armor for spectral wave attack. Influences of various statistical parameters such as wave height, peak spectral period, shape, and phasing are being investigated. Correlations with earlier monochromatic wave tests are being made.

PHOTO 1

BREAKWATER STABILITY STUDY

PHOTO 2

GENERAL VIEW OF 6-FT-WIDE SPECTRAL WAVE FLUME

PHYSICAL AND NUMERICAL MODEL INVESTIGATIONS OF FISHERMAN'S WHARF AREA, SAN FRANCISCO BAY, CALIFORNIA

The Fisherman's Wharf area is located in San Francisco Bay near the Golden Gate and is a well-defined segment of the San Francisco city waterfront. The area is bounded on the east by Pier 45 and on the west by the Municipal Pier. Existing development consists of a complex of commercial and recreational facilities. The Fisherman's Wharf area is a world-famed tourist attraction with a complex of recreational activities which receives in the tens of millions of visitors annually. The San Francisco Maritime State Historic Park is located on the Hyde Street Pier where five historic antique ships are on display to the public. Although part of a densely developed, heavily populated area with a network of piers, wharves, and berthing areas, Fisherman's Wharf is essentially unprotected from wave damage. Minimal protection provided by timber piers has diminished with the removal of deteriorated sections. During winter storms, wave energy from the open ocean (entering through Golden Gate) and local storms (waves generated by winds across the extensive water surface of the Bay), results in continual damage to fishing vessels and mooring facilities. Many fisherman have abandoned the harbor due to recurring boat damage. Waves also have caused damages to the historic vessels berthed in the area. Improvements are needed at the Fisherman's Wharf area to provide fishing vessel protection; historical vessel protection; and new, protected, recreational boating berths. Although numerous solutions to the problems and needs relating to harbor improvement in the Fisherman's Wharf area were analyzed, the most practical and feasible plan consists of a commercial fishing harbor enclosed by a concrete breakwater with solid and baffled sections to assure both adequate wave protection and water circulation.

At the request of SPL and the US Army Engineer District, San Francisco (SPN), an investigation was conducted by WES to:

(1) Determine the most economical breakwater configuration that would provide adequate protection for craft in the area from short-period waves.

(2) Determine the impact of reflections from the proposed breakwater with regard to erosion of the beach at Aquatic Park.

(3) Determine the impact of the proposed structures with regard to harbor response due to wave excitation for long-period waves entering through the Golden Gate.

(4) Develop remedial plans, as necessary, to alleviate undesirable conditions.

(5) Determine the impact of the proposed structures with regard to ship motion in the historical vessel mooring area.

PHOTO 1

PHOTO 2

FISHERMAN'S WHARF MODEL

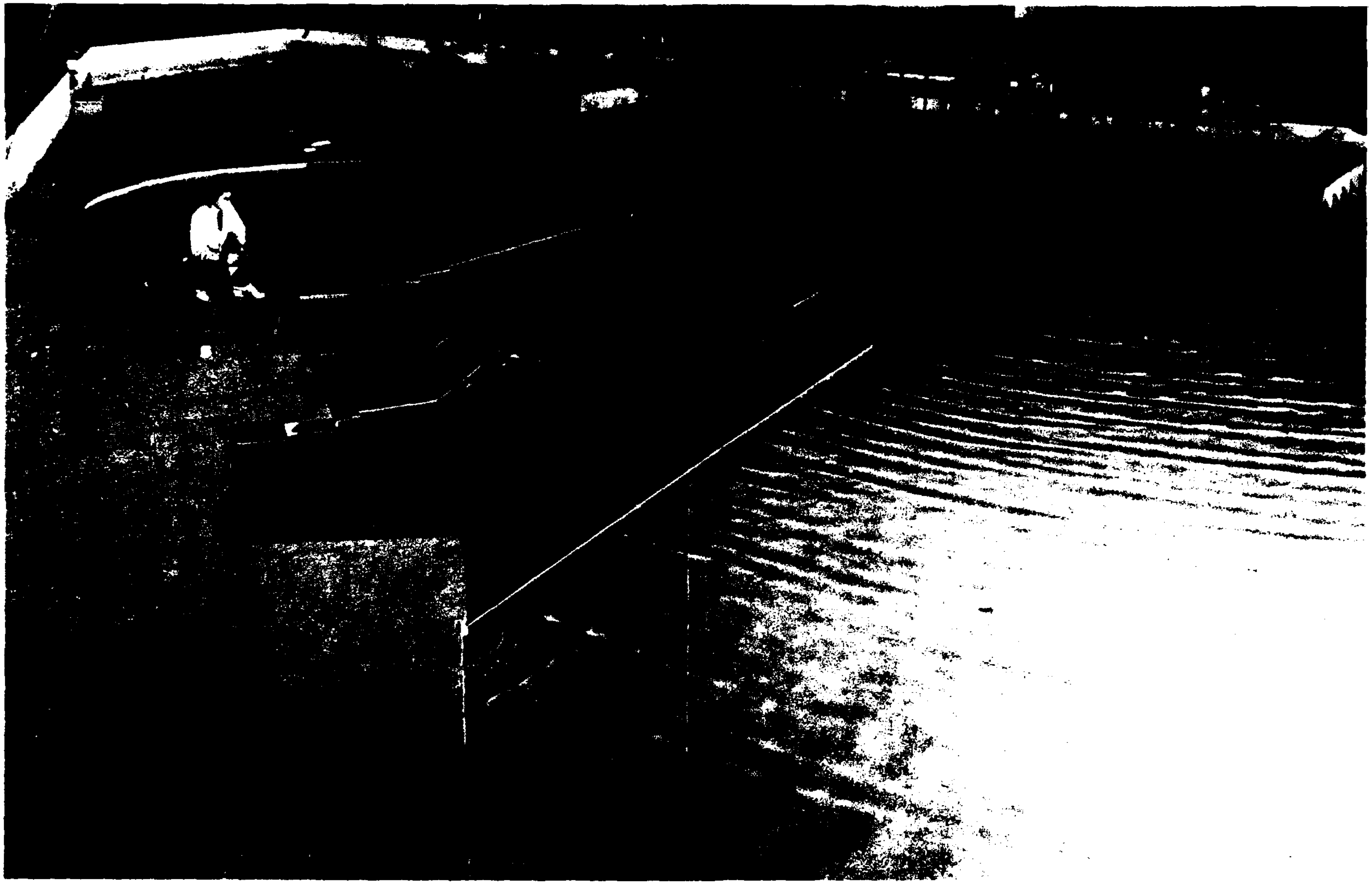

PHOTO 3

GENERAL VIEW OF 1:75-SCALE MODEL OF FISHERMAN'S WHARF

AUTOMATED DATA ACQUISITION AND CONTROL SYSTEM

An Automated Data Acquisition and Control System (ADACS) has been designed, procured, and installed to support CERC's experimental facilities. This system sends command signals to control model equipment during testing, monitors equipment feedback, receives and stores data signals from model sensors, and analyzes model data. The ADACS consists of a Digital Equipment Corporation (DEC) VAX 11/750 central processing unit, 80 multiplexed channels of analog to digital conversion, IEEE 488 interface for output to 61 channels of digital to analog, 121 megabyte fixed-disc storage, 10 megabyte removable-disk storage, and two 125-ips, 800/1,600-bpi, start/stop tape drives. The VAX system was selected for the following reasons:

(1) The powerful operating system readily supports multitasking for real-time applications.

(2) The system is used extensively in scientific applications.

(3) The system's capabilities offer good flexibility and expansion potential.

(4) The system's performance allows our software to be written exclusively in a high-level language (FORTRAN 77).

(5) The system's drivers are available for real-time peripherals.

(6) The system's performance allows many nonreal-time central processor unit (CPU) intensive applications (such as data analysis and wave board signal generation) to be executed locally. Adequate CPU time is available to incorporate real-time data analysis functions in the future.

The data acquisition software consists of multiple tasks executing concurrently to perform desired functions. Typical data sampling intervals are 60 samples/second/channel, and wave generator control is 20 updates/second/wave board. This system allows a computer operator, instrumentation technician, and model technician to completely control and conduct tests on one or a number of models as needed.

AUTOMATED DATA ACQUISITION AND CONTROL SYSTEM (ADACS)

MODEL STUDIES OF NOYO RIVER AND HARBOR, CALIFORNIA

Noyo River and Harbor are located on the California Coast in Mendocino County, approximately 135 miles north of San Francisco and 87 miles south of Eureka. The shoreline in the locality consists of broken, irregular cliffs about 40 to 80 ft high and numerous rocks extending several hundred yards offshore. Small pocket beaches are found at the heads of covers in the immediate vicinity. The Noyo River empties into Noyo Cove which is approximately 1,800 ft wide, north to south, and 2,000 ft long, east to west. The existing Noyo River and Harbor project was authorized by the River and Harbor Act of 1930, and construction was completed in 1961. It consists of a jettied entrance at the river mouth; a 10-ft-deep, 100-ft-wide entrance channel; and a 10-ft-deep, 150-ft-wide river channel extending upstream about 0.6 mile. Noyo Harbor is located on the south bank of the river at the upstream limit of the dredged river channel. A privately owned harbor (Dolphin Cove Marina) is located on the south bank approximately 1.1 mile upstream from the river mouth.

Noyo Cove is open to the Pacific Ocean and exposed to large waves generated by local coastal storms accompanied by storm winds (sea) and distant ocean storms without local winds (swell). Waves in excess of 20 ft in height approach the cove from the southwest clockwise through northwest directions. Heavy seas sweep across the cove and through the jettied river entrance making it impassable for entry or departure during these periods. In addition to these adverse wave conditions, the harbor has experienced strong surging problems due to long-period wave energy resulting in damages to small craft moored there. Shoaling in the river channel is experienced also due to the deposition of material brought down the river during the winter rainy season. This shallow river channel results in navigational difficulties, particularly upstream of Noyo Harbor. Vessels are subject to damage by grounding and are forced to wait for favorable tide conditions to provide adequate depths.

Improvements at Noyo River and Harbor would result in prevention of boat damage, a harbor of refuge for vessels during storm activity, increased recreational boating, and area redevelopment. Potential commercial benefits would include increased lumber processing (barging of wood chips to Eureka and finished lumber to Los Angeles) and commercial fishing (increased fish catch).

Authorization for improvements at Noyo River and Harbor was granted by the River and Harbor Act of 1962. Under this authorization, however, breakwaters were proposed to protect the outer cove for development. The breakwaters required were not economically feasible (due to the high cost of construction and maintenance) resulting in the project being transferred to an inactive category. The Water Resources Development Act of 1976 modified the 1962 project to provide for construction of up to two breakwaters without a specific location to protect the harbor entrance. The location of breakwaters in more shallow water would reduce construction costs significantly. The 1976 Act also included additional channel improvements (deepening, widening, and extending) as deemed necessary to meet applicable economic and environmental criteria.

At the request of SPN, a hydraulic model investigation was initiated by WES to:

(1) Study long-period and short-period wave conditions and flow conditions in the Noyo River and Harbor.

(2) Determine the most economical breakwater configuration that would provide adequate wave protection to the entrance.

(3) Provide qualitative information on the effects of the breakwaters on sediment moving down the river.

(4) Develop remedial plans for the alleviation of undesirable conditions as found necessary.

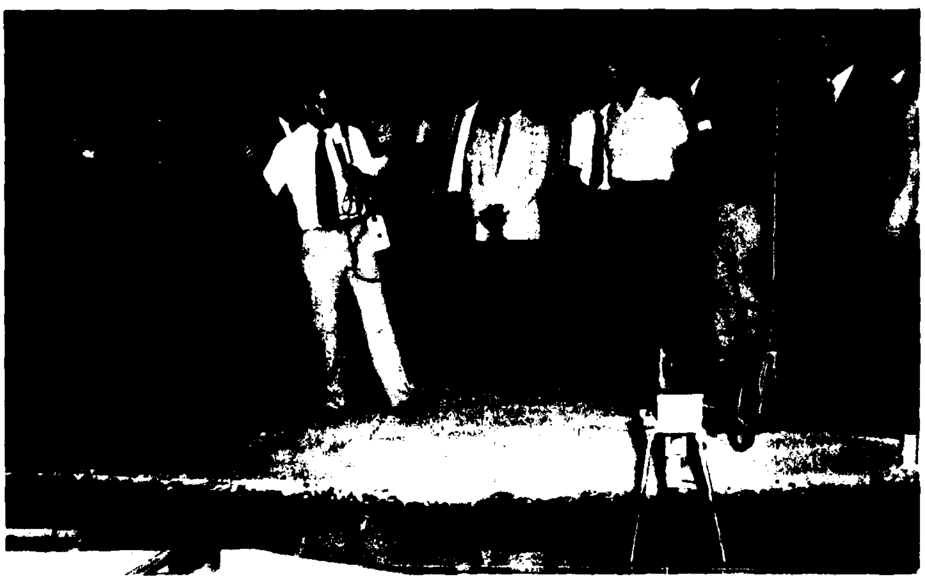

PHOTO 1

NOYO HARBOR MODEL

PHOTO 2

GENERAL VIEW OF 1:75-SCALE MODEL OF NOYO HARBOR

PORTABLE DIRECTIONAL SPECTRAL WAVE GENERATOR

A directional spectral wave generator recently was installed in a wave basin at CERC. The unique design provides a wave generator which can be relocated, as required, during testing. Local-sea and distant-swell spectra then can be combined over a broad range of differing directions of approach. The wave generator consists of 60 wave paddles, each 1.5 ft in width, for a total width of 90 ft. The wave paddles are driven at the paddle joints to reduce generation of spurious waves. The wave paddle displacement is in translational motion and is designed for water depths up to 2 ft. Displacement of each paddle is controlled independently by the ADACS that performs the functions of: (1) control signal generation, (2) model data acquisition, (3) generator performance monitoring, and (4) data analysis. The ADACS consists of a DEC VAX 11/750 computer with appropriate system peripherals. The addition of this generator will enhance greatly CERC's facilities. Significantly improved model data will be obtained for a broad range of coastal engineering site-specific studies and research investigations since the interaction of wave trains from multiple directions and directional spreading of wave energy can be included in future studies.

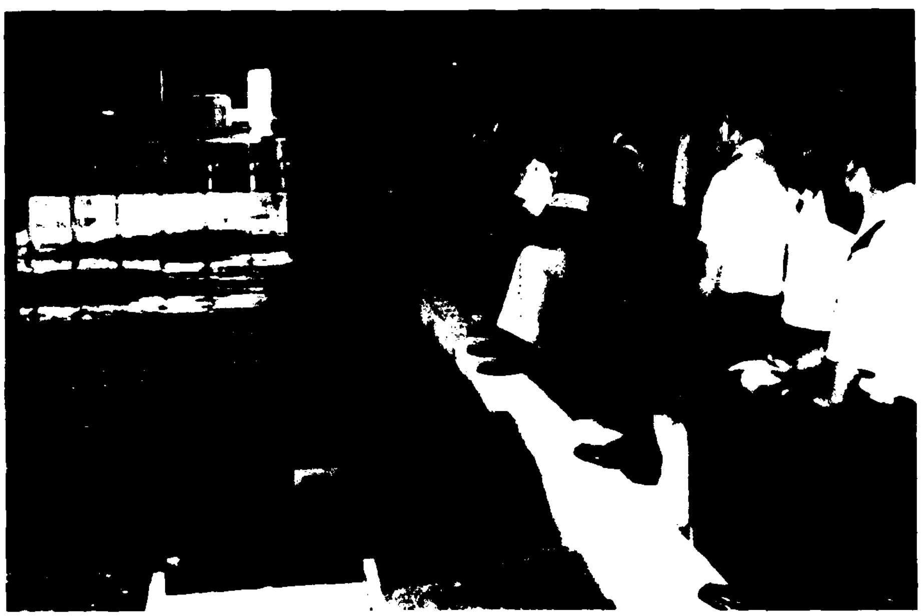

PHOTO 1

DIRECTIONAL SPECTRAL WAVE GENERATOR

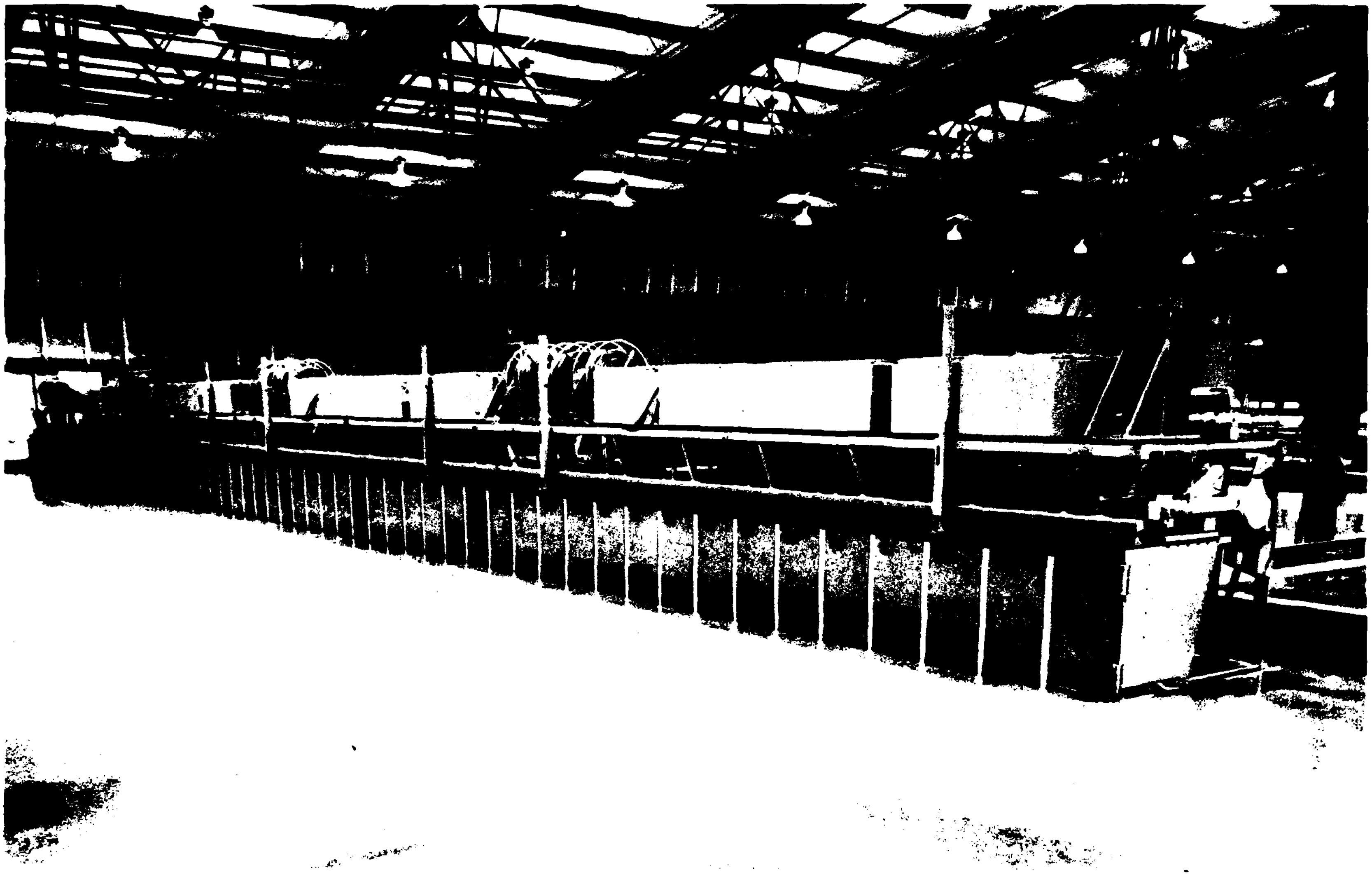

PHOTO 2

GENERAL VIEW OF DIRECTIONAL SPECTRAL WAVE GENERATOR

WAVE RUNUP AND OVERTOPPING TESTS OF ROUGHAN'S POINT SEAWALL IN 3-FT SPECTRAL WAVE FLUME

Recent studies in the 3-ft-wide glass-walled wave flume have treated wave overtopping of seawalls for the New England Division (NED). Roughan's Point, a small community just north of Boston, is subject to flooding due to wave overtopping of the existing seawall during northeaster storms. A proposed method of reducing wave overtopping is to use a riprap revetment fronting the seawall to dissipate wave energy. Several seawall/riprap configurations have been tested, and the laboratory work for NED has been completed. Generally it was found that using a riprap slope in front of the seawall will cut the overtopping rate almost in half.

Because of the effort required to adapt the 3-ft wave tank for studies of wave overtopping rates due to irregular waves, it was decided to continue tests of this type in the facility. The new phase of testing will be of a more general nature. This phase will attempt to determine the influence on overtopping of a recurved seawall versus a plane seawall and various revetment configurations fronting the seawall versus no revetment as well as to develop wave overtopping rating curves for all the configurations tested.

PHOTO 1

WAVE RUNUP AND OVERTOPPING STUDY

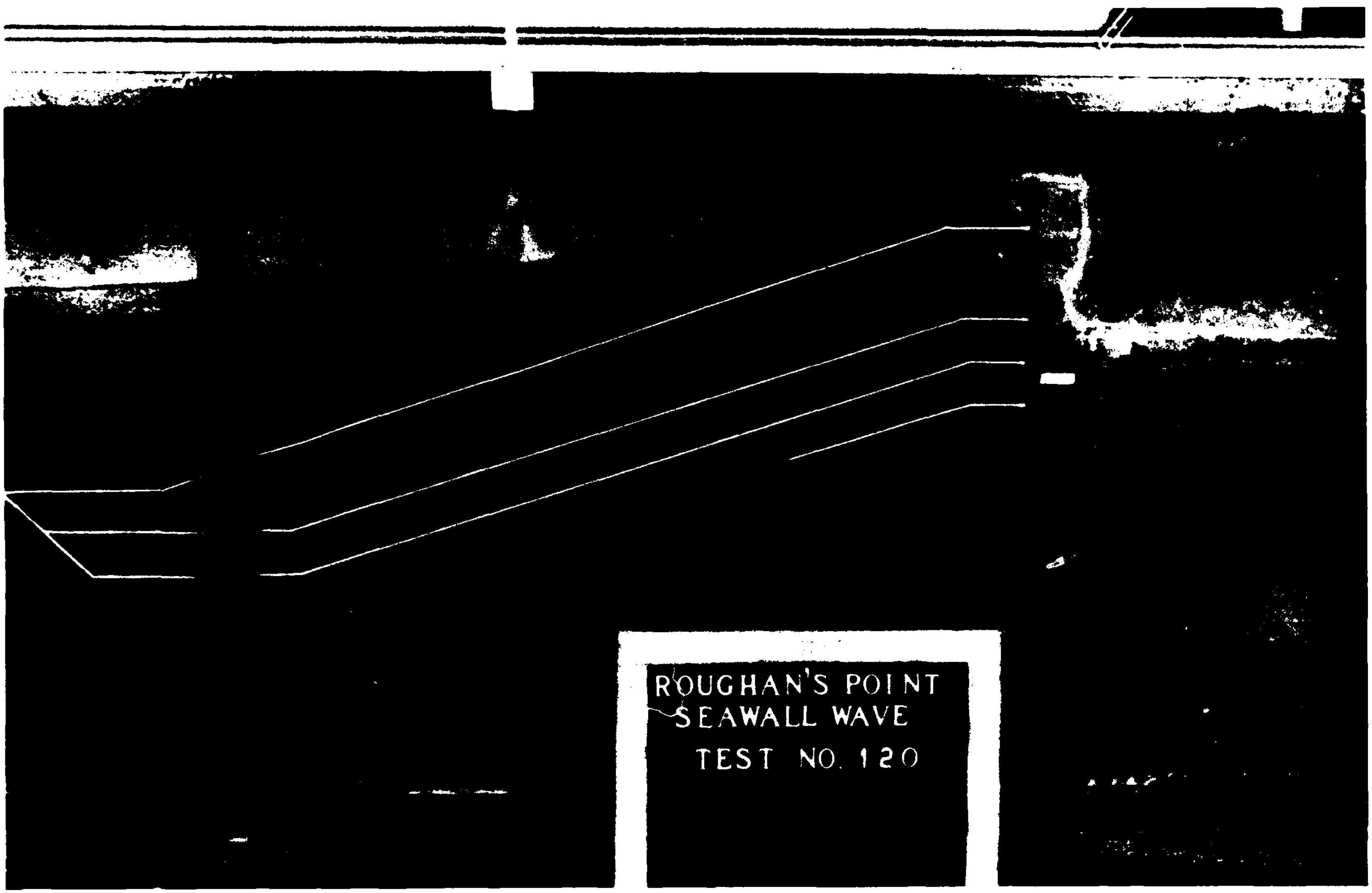

PHOTO 2

MODEL STUDY OF WAVE RUNUP AND OVERTOPPING, ROUGHAN'S POINT SEAWALL, ROUGHAN'S POINT, MASS.

MOVABLE BED MODELING RESEARCH BEING CONDUCTED IN 1.5-FT-WIDE SPECTRAL WAVE FLUME

The purpose of research being conducted in the 1.5-ft-wide flume is to evaluate various movable-bed model scaling relationships which have been proposed by various researchers. At present, five different sets of scaling laws are being evaluated using prototype data generated by T. Saville in 1957 using monochromatic waves in a large wave tank. The scaling guidance being evaluated includes the relationships proposed by E. K. Noda, P. Vellinga, Lepetit and Leroy, S. A. Hughes, and R. H. Hallermeier. Each of these five relationships will be used to model both erosive and accretive conditions. To date, approximately 20 tests have been completed using the 1.5-ft-wide flume, and approximately 20 more are scheduled. As suggested by W. Kamphuis of Queens University (one of the world's foremost experts in movable-bed modeling), fine sands are being used as the model sediment. In addition to the information concerning movable-bed modeling design, valuable data for use in wave runup prediction also have been obtained from these tests. Completion of testing in this facility is scheduled for 31 May 1985 with distribution of a draft report scheduled for 31 August 1985.

SIDE VIEW OF 1.5-FT-WIDE FLUME USED FOR MOVABLE BED MODELING RESEARCH

FUTURE FACILITIES PLAN FOR THE COASTAL ENGINEERING RESEARCH CENTER

CERB Proceedings

Mr. Charles C. Calhoun, Jr., Assistant Chief
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

Since being moved from Fort Belvoir in 1983, personnel of the Coastal Engineering Research Center (CERC) have been housed in various buildings at the US Army Engineer Waterways Experiment Station. This paper details plans for eventually centralizing all CERC personnel in one complex. Work will be accomplished in three phases.

EXPANSION OF OFFICE/LABORATORY FACILITIES

Introduction

The Coastal Engineering Research Center (CERC), which moved to the Waterways Experiment Station (WES), Vicksburg, Mississippi, in July 1983, currently is housed in Building 3296 and several other buildings located at WES. In an effort to increase efficiency among CERC operations and to reduce energy costs, plans and cost estimates have been prepared to extend the size of the existing Building 3296 from approximately 9,900 sq ft to 51,300 sq ft (Figure 1).

The expansion plan consists of a three-phase addition to Building 3296, with Phase I and Phase II having an architectural scheme similar to that of the existing building. Phase I and Phase II consist primarily of office space, while Phase III is primarily laboratory and equipment staging areas. Each phase is designed to allow for separate construction of the other phase.

Phase I Building Extension

The Phase I building extension is under way and is located south of the existing Building 3296. The addition will have overall dimensions and architecture similar to those of the existing building. Figures 2 and 3 show the floor plan and architectural elevations, respectively. Occupancy of the Phase I extension by personnel from the Research Division will allow us to abandon two antiquated office areas and relieve overcrowding in a third. The

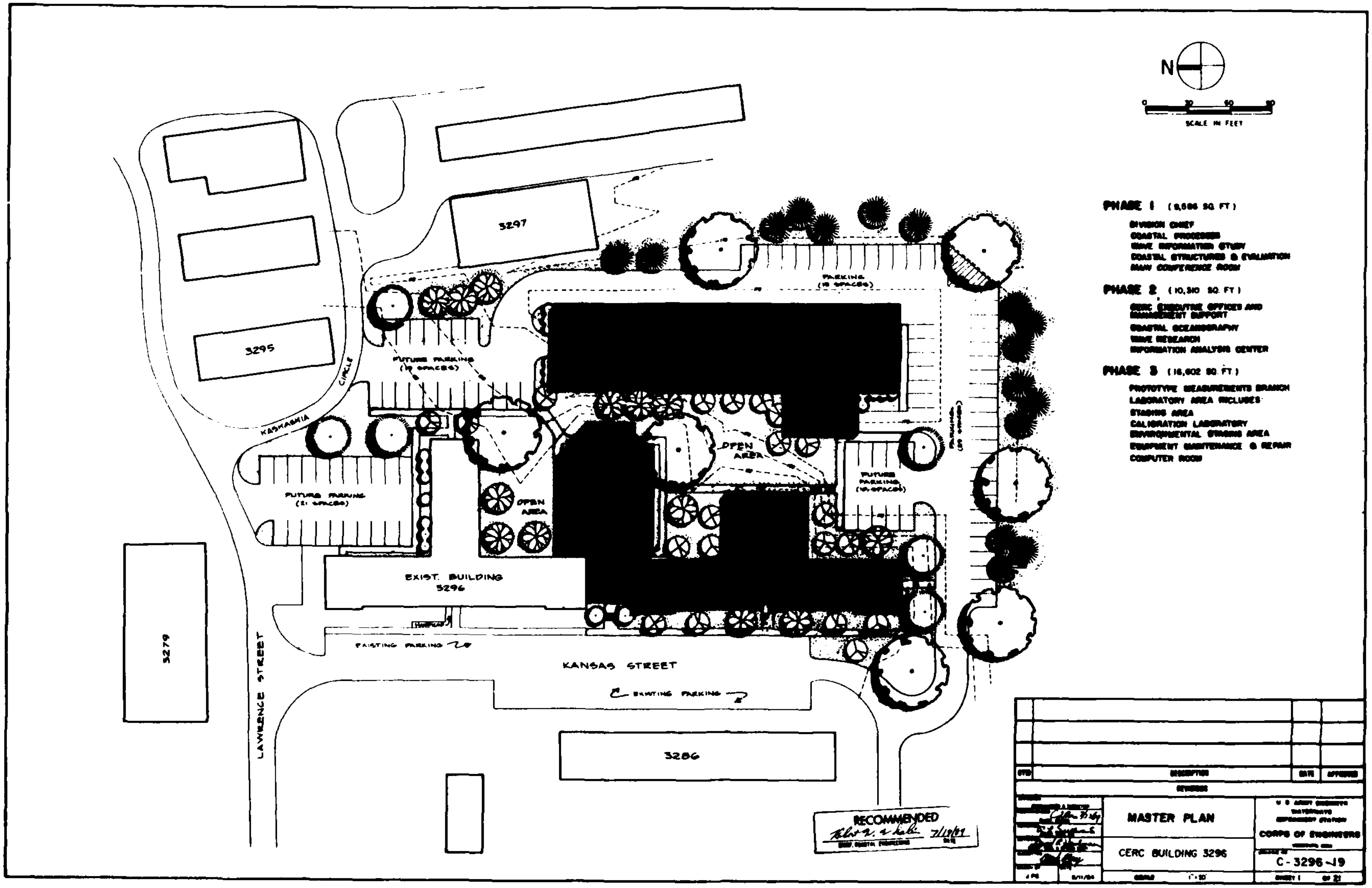

FIGURE 1. CERC BUILDING 3296 AND PROPOSED ADDITIONS

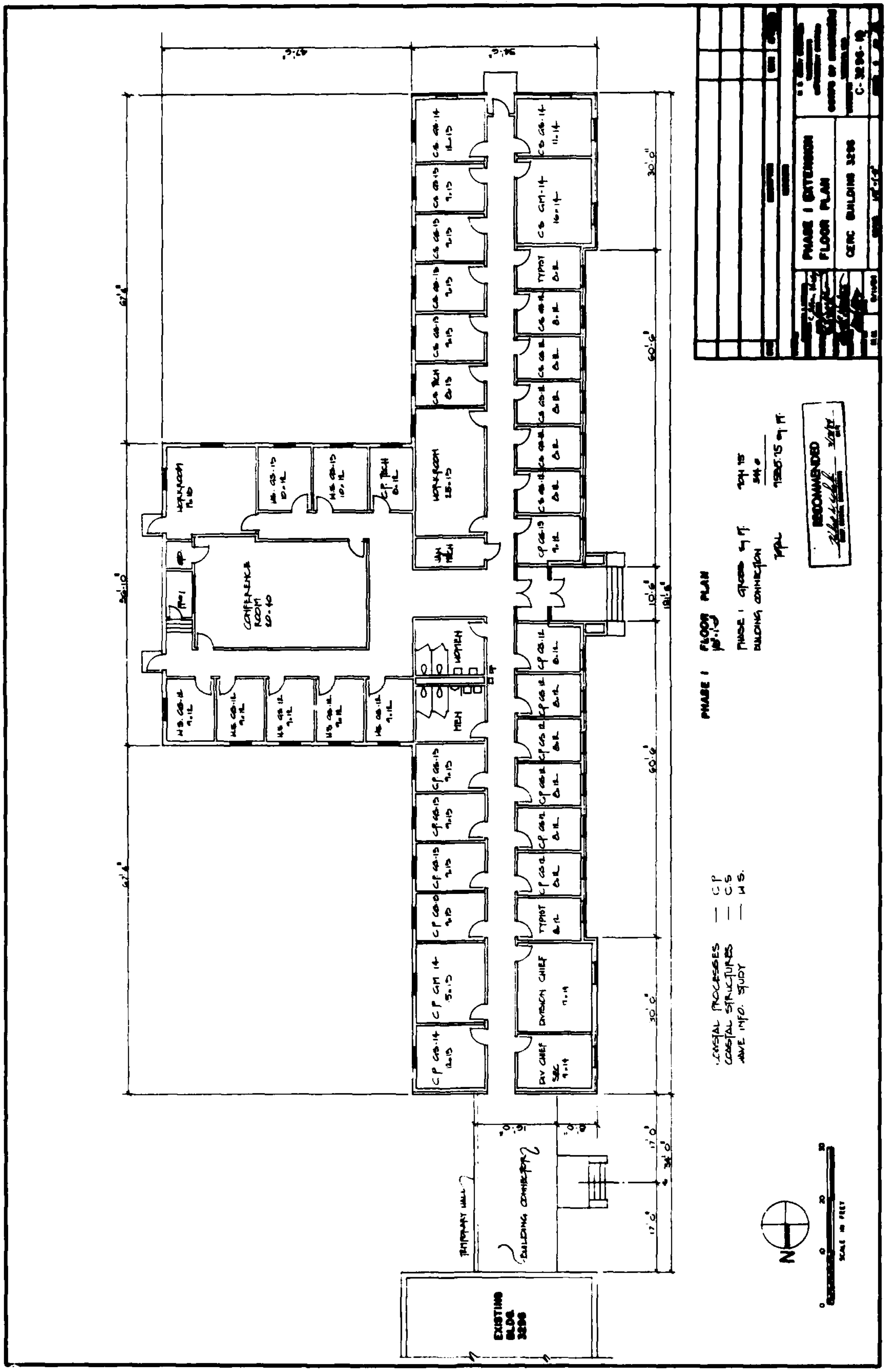

FIGURE 2. FLOOR PLAN OF PHASE I

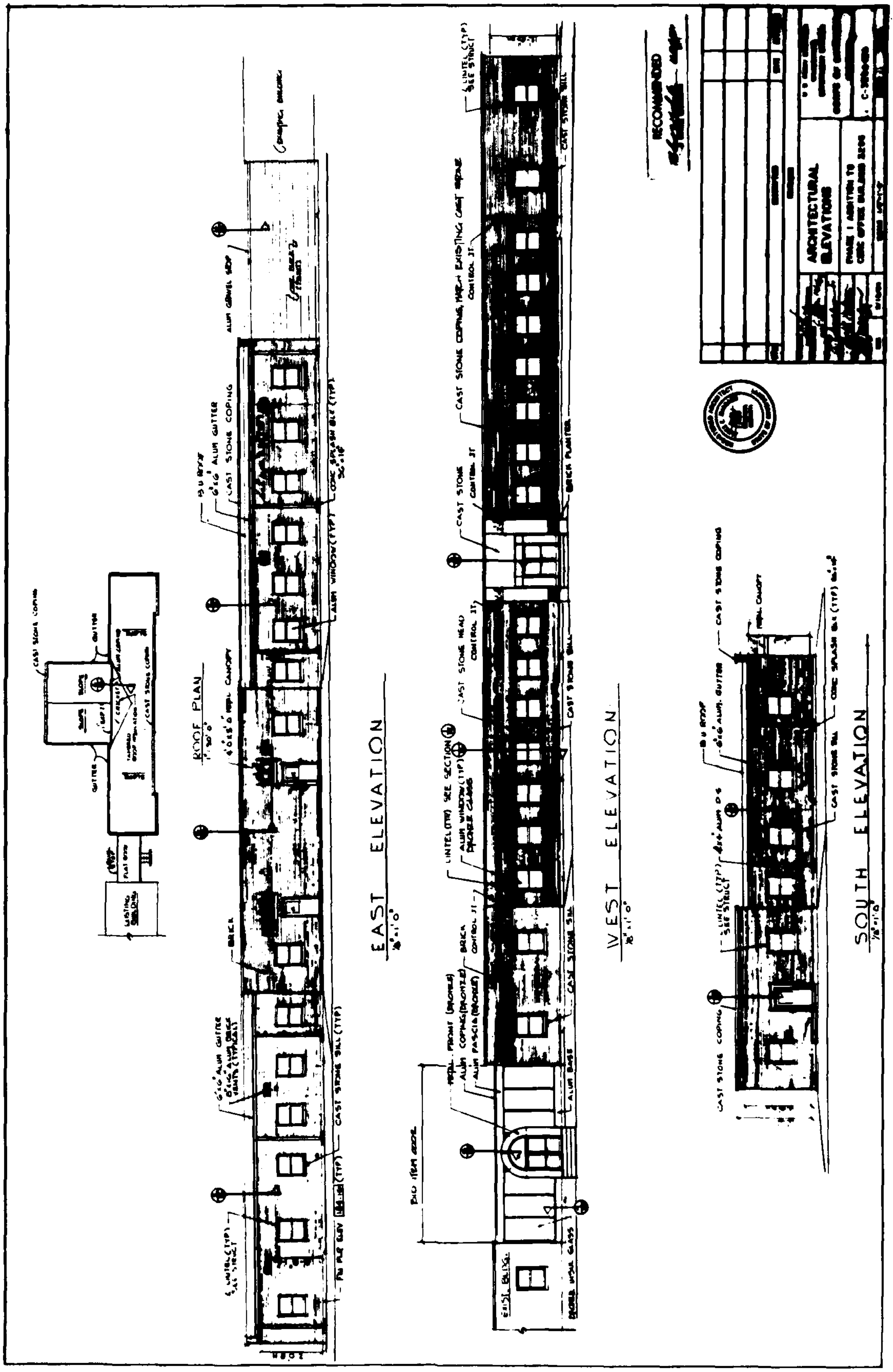

FIGURE 3. EAST, WEST, AND SOUTH ELEVATIONS OF PHASE I

Phase I building extension will be connected to the existing Building 3296 by an enclosed structure that eventually will be the main entrance to CERC headquarters. This connector will have a glass front and will serve to connect the Phase II extension to the existing buildings.

Phase II Building Extension

The Phase II building extension will be located east of the new main entrance and, as such, will be connected to the existing Building 3296 and the Phase I extension. The Phase II extension will be a three-story, 15,500-sq-ft building and will house the CERC executive offices, management support personnel, and portions of the Wave Research Division and Engineering Development Division. This phase is included in WES's Plant Replacement and Improvement Program (PRIP) budget for fiscal year 1987 (FY 87) and FY 88. At this time, we have no detailed plans from the architect.

Phase III Building Extension

The Phase III building extension will be located east of Phases I and II and a will contain the Prototype Measurement and Analysis Branch and laboratory area. The laboratory area will include the calibration lab, environmental staging area, equipment maintenance and repair area, and computer room. Figures 4 and 5 show the floor plan and architectural elevations, respectively. Construction of Phase III will be initiated later this FY and will be completed in FY 86.

Summary

The construction of this master plan office/laboratory complex will allow CERC to centralize its engineers, scientists, and administrative personnel in highly efficient work groups, while providing significant energy savings. An important side benefit will be improved employee morale and an improved ability to attract and keep highly qualified personnel.

EXPANSION OF EXPERIMENTAL FACILITIES

All CERC experimental facilities are filled to capacity with considerable backlog in many areas. The most pressing needs are for additional facilities to conduct three-dimensional stability tests and conversion of all existing wave generators to spectral capability. Figure 6 shows planned expansion of CERC's experimental facilities during the period 1986-1991. In addition to the two- and three-dimensional basins shown here, our requested PRIP budget

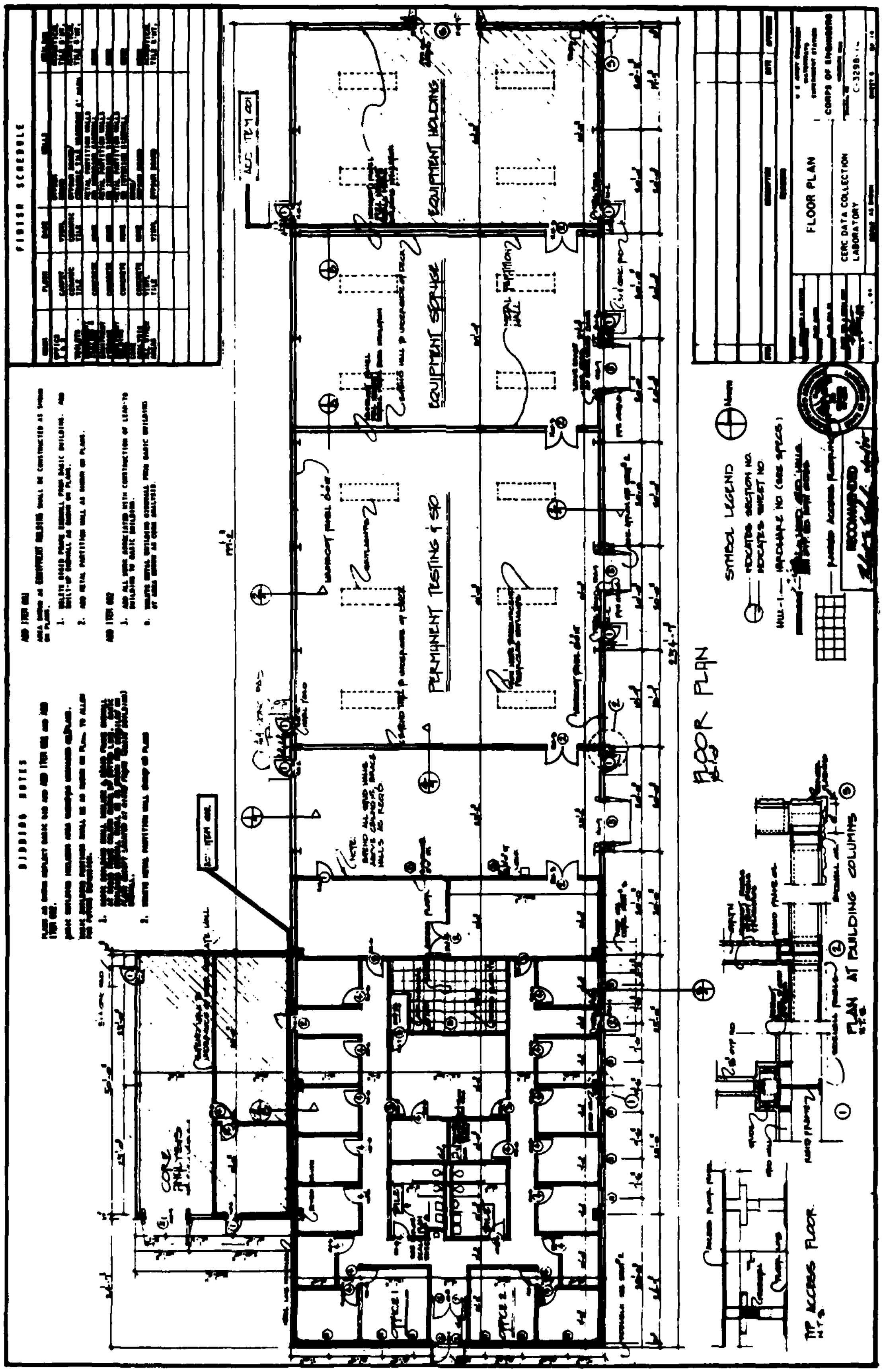

FIGURE 4. FLOOR PLAN OF PHASE III

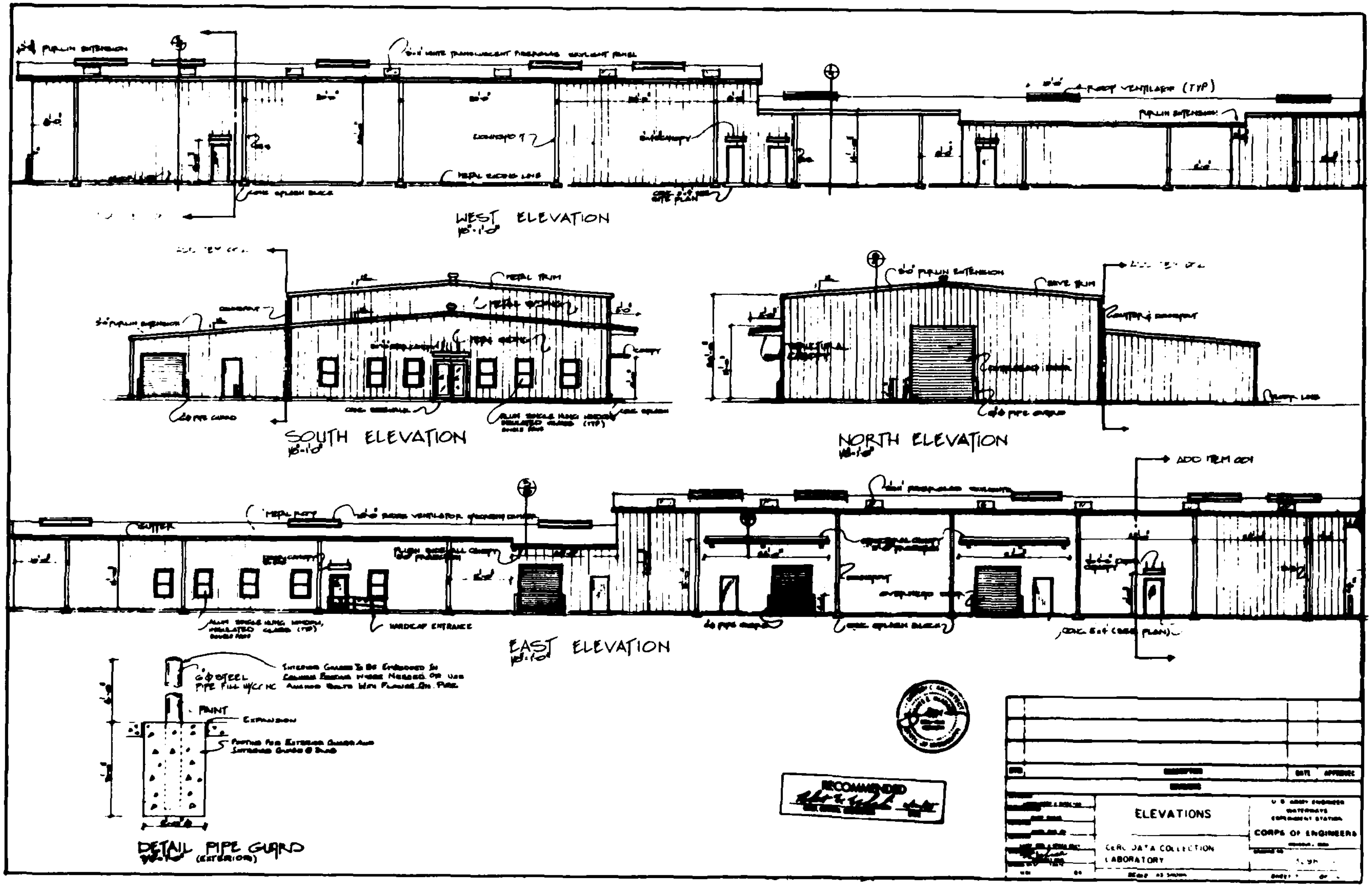

FIGURE 5. WEST, SOUTH, NORTH, AND EAST ELEVATIONS OF PHASE III

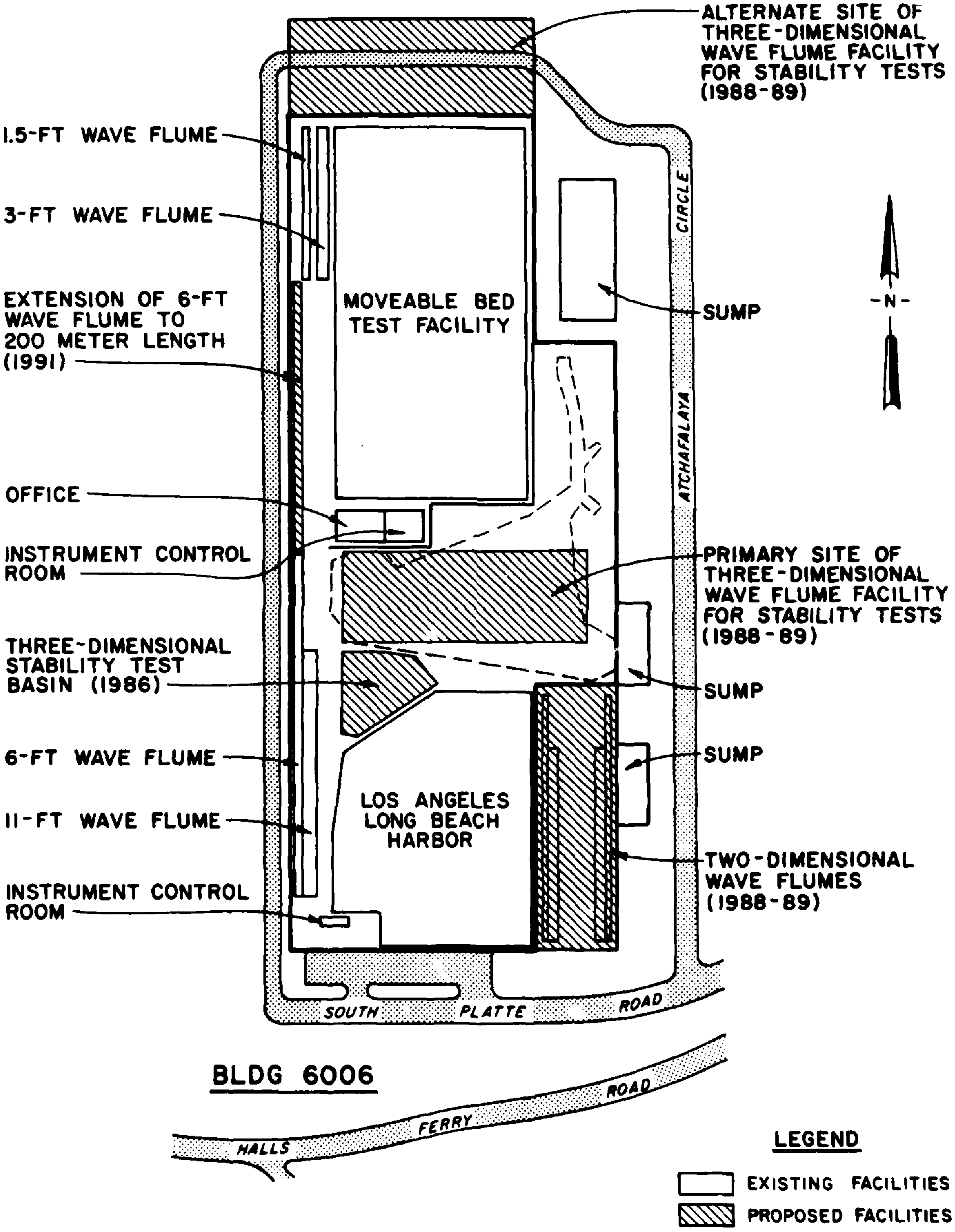

FIGURE 6. FUTURE EXPANSION PLAN FOR CERC EXPERIMENTAL FACILITIES

calls for conversion of at least one monochromatic wave generator per year to spectral capability. We hope to have this conversion complete within 5 years.

DISCUSSION

DR. WHALIN: You might want to add, Charlie, that our No. 1 laboratory request next year is to convert our generator in the "L"-shaped wave flume that you saw this morning to a spectral generator. I'm quite sure it will be high enough in the priority to make it all the way through the system, or I would be quite surprised if it didn't.

MR. CALHOUN: The No. 1 item that we submit normally gets funded.

DR. WHALIN: That's a relatively safe assumption, but at least that's what we view as our top priority laboratory equipment.

PROF. WIEGEL: I'd like to go on record supporting that because I think it's really necessary for you to have a spectral generator for that facility. It's almost a waste of time nowadays to use a periodic wave for that sort of test.

DR. WHALIN: We appreciate that.

Proceedings

RESEARCH PROGRAM FOR DIRECTIONAL SPECTRAL WAVE GENERATOR

Dr. James R. Houston, Chief
Research Division
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The US Army Engineer Waterways Experiment Station's Coastal Engineering Research Center has prepared a research program for its directional spectral wave generator (DSWG). An ad hoc committee is responsible for selecting and establishing priorities for research and mission support studies requiring the DSWG. The three general categories of studies requiring use of the DSWG are developmental, research, and mission support studies. This paper presents examples of studies that will be performed in the near future. These studies include a developmental study to alleviate the problem of parasitic waves accompanying wave groups, a research study on interacting nonlinear waves, and a military mission support study.

INTRODUCTION

The directional spectral wave generator (DSWG) recently accepted from the contractor by the US Army Engineer Waterways Experiment Station's (WES's) Coastal Engineering Research Center (CERC) provides the US Army Corps of Engineers (Corps) with unique capabilities to investigate effects of directional wave spectra in the coastal zone. The mechanical design of the DSWG, its capabilities, and the automated data acquisition and control system supporting it were described during the 41st Coastal Engineering Research Board meeting in Seattle, Washington. This paper will discuss the planned research program for the DSWG.

An ad hoc Research Committee has been established to coordinate use of and obtain maximum benefits from the DSWG. The committee is chaired by Mr. C. E. Chatham, Chief, Wave Dynamics Division. Committee members are Dr. James R. Houston, Chief, Research Divison; Mr. Douglas G. Outlaw, Chief, Wave Processes Branch; Dr. Edward F. Thompson, Chief, Coastal Oceanography Branch; Dr. Todd L. Walton, Research Hydraulic Engineer, Coastal Structures and Evaluation Branch; Dr. Michael E. Andrew, Statistician, Prototype Measurement and Analysis Branch; and Mr. Michael J. Briggs, Hydraulic Engineer, Wave

Processes Branch. The committee is responsible for selecting and establishing priorities for research and mission support studies requiring the DSWG.

STUDIES USING DSWG

The three general categories of studies requiring use of the DSWG are developmental studies, research studies, and mission support studies. This paper will present a general overview of planned studies in each of the three categories along with more detailed discussions of specific studies. These studies will be performed in the near future, and the discussion will address reasons the studies require the special capabilities of the DSWG.

Developmental Studies

The mechanical motion of the DSWG, interactions of the motion with water, and interactions of the resulting waves with the basin are very complex. Therefore, research is required to achieve the full potential of the DSWG. Developmental studies planned for the near future include the following:

(1) Software development for generating particular waveforms (e.g., sea/swell combinations, interacting cnoidal waves).

(2) Establishment of optimal characteristics of the generated directional seas (e.g., number of directional components in each frequency and types of spreading functions).

(3) Elimination of laboratory problems such as parasitic waves accompanying wave groups.

(4) Laboratory measurement of directional seas.

(5) Quantification of basin response to waves.

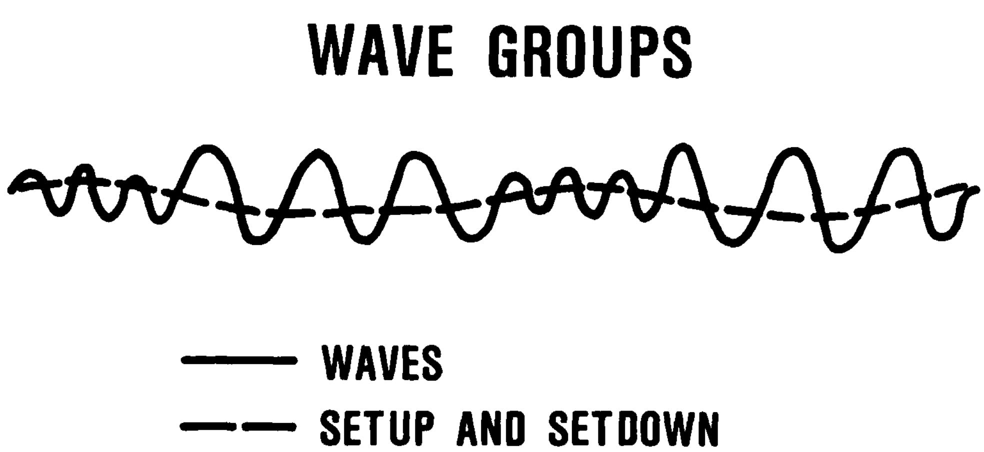

FIGURE 1. TYPICAL WAVE GROUPS

Elimination of laboratory problems such as parasitic waves accompanying wave groups is necessary to effectively use the DSWG to solve coastal problems. It is well known that waves travel in groups (Figure 1). There has been considerable speculation on the effects of wave groups on coastal structures and processes. Longuet-Higgins and Stewart (1964) have shown radiation stresses result in setdown under the larger waves of a group and setup under the smaller waves (Figure 1). The setup and setdown phenomena will naturally occur in wave groups generated by the DSWG. However, if the DSWG merely reproduces the short-period waves of a wave group, the generator is an improper boundary condition for the setup and setdown; consequently, the DSWG generates spurious free long waves sometimes called parasitic waves. This phenomenon has been noted in laboratories using spectral wave generators, and methods have been developed to program the generator motion to alleviate the problem. Directional spectra add another level of complication over nondirectional spectra, and work will be required to allow generation of wave groups without parasitic waves.

Research Studies

CERC has planned a very active research program using the DSWG. It can be used to understand the phenomenology of wave propagation in shallow water and interactions of waves with structures and sediment. In addition, CERC has developed numerical models in recent years that consider directional spectral wave propagation. The DSWG can be used for controlled experiments which establish the validity of models or their components or indicate model weaknesses. Research study topics planned for the near future include the following:

(1) Shallow-water wave transformations.

(2) Refraction, diffraction, and attenuation of directional spectral waves.

(3) Wave groups and applications to coastal design.

(4) Nonlinear wave interactions in shallow water.

(5) Interaction of directional waves with structures.

(6) Harbor response to directional waves.

(7) Sediment transport by directional spectral waves.

This summer CERC is planning an experiment on nonlinear wave interactions in shallow water. The study will be funded by a work unit in the In-house Laboratory Independent Research (ILIR) program, the Laboratory

Simulation of Spectral and Directional Spectral Waves work unit, and the National Science Foundation (NSF). The ILIR program is a small and highly competitive WES program for basic research funded by the Department of the Army. Professor Joseph Hammack from the University of Florida will participate also with funding from both the NSF and CERC.

The DSWG will be used to verify an important new theory of nonlinear waves. The Korteweg and deVries (KdV) equation has been used for many years to study weakly nonlinear and dispersive waves. A wide variety of phenomena ranging from plasma waves, atomic lattice vibrations in solids, and water waves in shallow water have been found to be governed under certain conditions by the KdV equation. Wiegel (1960) transferred cnoidal wave solutions of the KdV equation from the realm of mathematics to practical coastal engineering. However, the KdV equation is one-dimensional. A new two-dimensional theory has been developed by Kadomtsev and Petviashvili (KP). Solutions of the KP equation for simple conditions have been derived, and extensions to more complex conditions are being investigated.

The KP equation predicts unusual nonlinear effects for waves propagating through each other (sea and swell waves propagating in different directions or interactions of incident and reflected waves are typical examples). For example, Figure 2 shows a typical pattern for waves moving through each other with no strong nonlinear interactions. However, the KP equation predicts strong interactions as cnoidal waves pass through each other. A Mach-Stem effect (Wiegel, 1964) is predicted at wave intersections as the cnoidal waves pass through each other (Figure 2). The DSWG will be used to test the predictions based upon the KP equation.

Although these experiments are more basic than most research at CERC, there are many potential practical engineering benefits that may be derived. When the theory has been verified and solutions derived for complex conditions, efforts are planned to provide information in a form analogous to the work of Wiegel (1960) for cnoidal wave solutions of the KdV equation. Just as Wiegel's work made one-dimensional cnoidal wave theory available for engineering applications, the new theory promises to make two-dimensional cnoidal wave theory available for practical engineering application.

Mission Support Studies

There are many potential mission support studies for various District and Division offices that may require the unique capabilities of the DSWG. In

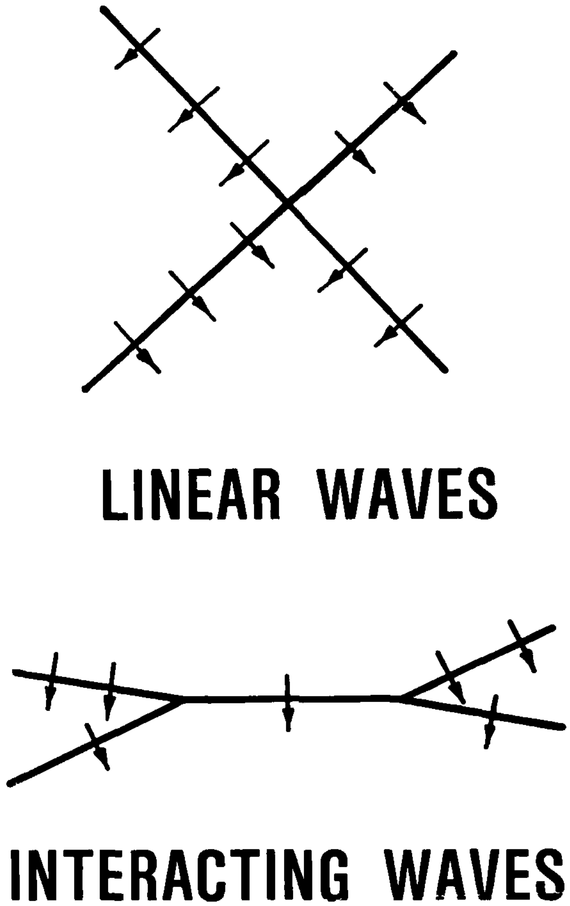

FIGURE 2. TYPICAL PATTERNS FOR WAVES MOVING THROUGH EACH OTHER

addition, CERC is planning military mission support work in the near future which requires both the physical scale modeling expertise of CERC and the capabilities of the DSWG.

CERC has been involved in an explosion-generated water wave program for the last 5 years for the Defense Nuclear Agency (DNA). Past work has involved numerical modeling and field work relating to explosion waves. More recently, CERC has been involved in a series of classified meetings with DNA, the US Navy, and other agencies concerning an explosion-generated wave study that requires CERC's physical scale modeling capabilities and the DSWG. Since CERC's DSWG is unique in this country, the Corps will be providing a unique resource as part of its military mission.

SUMMARY

In summary, the DSWG is an exciting new tool that CERC plans to use in a variety of ways to understand coastal processes, provide unique information to establish the validity of theories and numerical models, aid in establishing design criteria for coastal engineering works, and simulate real world wave conditions in scale models. There is strong demand by research and mission support studies to use this unique wave generator. As a result, CERC has formed an ad hoc committee to ensure the DSWG will be used in the most efficient manner to address Corps needs in coastal engineering.

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DISCUSSION

PROF. WIEGEL: *It's really great to have been out there and to have seen that it's there and starting to work. I think this is one of the real major steps forward to finally getting one of these in the United States. I think maybe my mind will be set at ease because when I saw Joe Hammack's name appear one fundamental thing was in my mind—whether or not this sort of interaction would come out of directional spectral or not. Now Hammack has worked in KdV, but he's also worked on the edge wave. Which aspect was he going to work on?*

DR. HOUSTON: Well, we're looking at generating tank waves, moving through each other and looking at where they intersect.

PROF. WIEGEL: *You will be looking at that part?*

DR. HOUSTON: We won't be looking at the edge wave.

PROF. WIEGEL: *Okay, I think an edge wave is even more fundamental than any of these. When you have a wave tank and you generate cylindrical waves, you've got two effects that you usually don't want. Then you have to map your system so that you can run your test and stable solutions. I forget the name of the two people who wrote the paper on where the waves become unstable as they move down the tank a great distance. That's one instability. Does this thing occur in directional spectral? The second instability is the actual generator. As you know, there are certain times that you get the eigenvalue solutions where if you have the double frequency or half frequency waves that are generated also you have an irregular wave at the generator. And I think that these two things are even more fundamental than anything else you do afterwards.*

DR. HOUSTON: Right. We'll be doing work to make sure we can generate very

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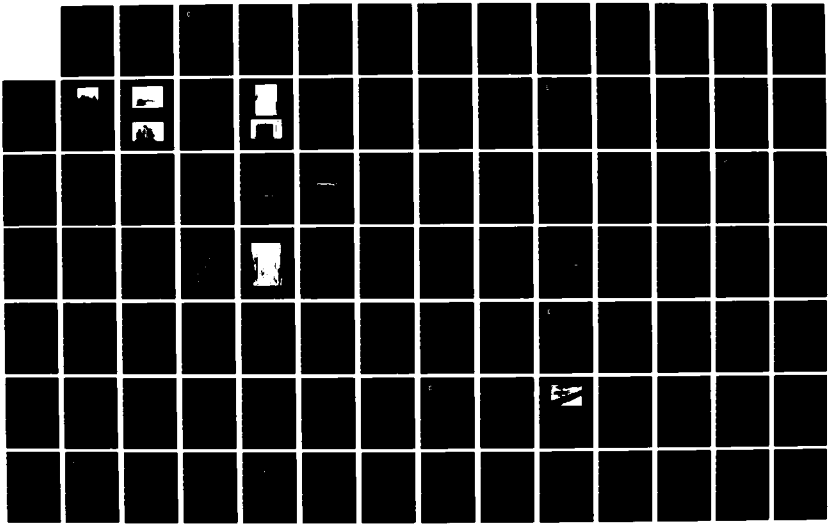

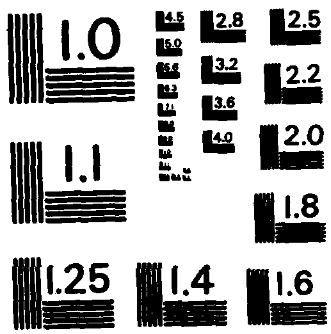

MICROCOPY RESOLUTION TEST CHART
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clean cnoidal waves. Of course, there are all kinds of laboratory and basin effects. People who have worked in the laboratory, you know, know there is just a wide range of problems that can be developed and problems related to the basin itself. You can get standing waves developing and edge wave effects. Reflections come off the basin walls, and where you take your measurements and how long you test are very critical.

Professor Joe Hammack is one of the experts, I think, in laboratory work in this country. He'll be coming down next month, and he'll be staying about a month down here working with us on it. I think this is the kind of study that will be very prominent. I would anticipate that it would be published in the Journal of Fluid Mechanics because these KP equations have been popular in recent years, but work hasn't been done to try to verify them because of lack of equipment like this. But we anticipate a lot of laboratory type effects. It's going to be a lot of work. So it will be over the next couple of years before we understand everything there is to know about it.

DR. NUMMEDAL: *In terms of sediment transport studies, I presume that the greatest interest would be in shallow-water beaches and in the nearshore zone. That will get us back to what we read in this book about your long-period standing waves being your edge waves. Do you think you will be able to effect a model in a realistic way for sediment transport in the surf zone?*

DR. HOUSTON: That will be very difficult. That's why the Phase I studies will be wave studies. But eventually I think we will have to get into sediment transport studies, and, of course, there are all kinds of problems that get eliminated before you do that type of work. You know, a few months ago we had Professor Kamphuis come down from Canada, and he's probably the world's expert in model waves, in physical modeling and sediment transport. He told us how long it took him in his basin before he could understand all the different types of effects and how he tried to compensate for them. And still, of course, there are always problems to be solved. That's probably a little bit farther down the road, but it will be an area we'll have to get into. It will be shallow-water beach problems. We have Dr. Nick Kraus who joined us from Japan last year, and he's done quite a bit of work in Japan on small-scale laboratory work.

DR. WHALIN: Let me add one thing. Since we wanted to talk about our R&D program at this meeting, what we have done is highlighted one work unit in each of our four R&D programs. So we just picked a work unit that we chose to highlight. The next four presentations that you are going to hear entail one work unit out of each of the four programs. We don't have time, of course, to go into any detail on the total program, so what we decided to do was to give you some technical detail on one work unit in each of the four programs, as opposed to the overall view that I've given you before (see Appendix E for narrative rationales and spreadsheets for the four work units).

WAVE ESTIMATION FOR DESIGN

CERB Proceedings

Dr. Steven A. Hughes
Research Hydraulic Engineer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The work unit "Wave Estimation for Design" strives to develop better understanding of shallow-water wave growth, propagation, and decay and to transform this knowledge into engineering methods for wave estimation. This paper briefly summarizes past significant research achievements and describes future plans. One recent research result and one planned effort are spotlighted in detail as examples of the applied research conducted in this work unit.

INTRODUCTION

Despite recent advances in the understanding of nearshore wave behavior, there still remain many unanswered questions pertinent to the design, construction, operation, and maintenance of coastal projects. For example, the US Army Corps of Engineers (Corps) hindcasting and measurement programs provide accurate wave estimates, but it is often necessary to transform these results to the project site over complex bathymetry. Another common situation is the task of providing reasonably accurate design wave estimates in regions where no historical hindcasts or measurements exist. Providing engineering solutions to these and other wave estimation problems, as well as improving existing wave estimation techniques for use in the design, construction, operation, and maintenance of coastal projects, is the major thrust of the work unit titled "Wave Estimation for Design" in the Coastal Flooding and Storm Protection Program, Coastal Engineering Functional Area, at the Coastal Engineering Research Center (CERC). Fundamental to this objective is, on the one hand, the need to understand the basic physical process behind wave generation, propagation, and decay in shallow water and, on the other hand, to provide the Corps field elements with the necessary design aids to make these estimates.

Past Accomplishments

Since 1980 the various researchers who have worked in or managed "Wave

Estimation for Design" have achieved considerable progress toward the work unit's objective, both in fundamental understanding and in end-user products.

Several different computer numerical models for use in wave estimation over complex bathymetry have been made available for Corps use, from simple propagation models to advanced shallow-water time-dependent spectral wave growth models. These numerical models have typically undergone evaluation, testing, and verification before finally becoming available as working tools for the Corps field elements.

In 1980 researchers participated in the successful Atlantic Remote Sensing Land-Ocean Experiment (ARSLOE). This multiagency, international effort produced a premium quality data set which has proven instrumental in the development of new approaches to shallow-water wave transformation. Intercomparisons between wave measuring devices were made, and some new wave measuring techniques, such as the Coastal Ocean Dynamics Applications Radar (CODAR), were field tested during the ARSLOE. A number of technical papers have since appeared in print, including a special ARSLOE issue of the Institute of Electrical and Electronic Engineers Journal of Oceanic Engineering. Credit for the success of ARSLOE goes to CERC, as a whole, and to the outside participants, not to just a single work unit.

Other progress includes results on wave height distributions, wave grouping, wave direction from radar, interpretation of spectra, long-term distribution of significant wave heights, definition of wave height parameters, evaluation of various wave estimation methods, and development of a new shallow-water self-similar spectral form. Nearly two dozen technical publications have been produced in this work unit ranging from short, informative Coastal Engineering Technical Notes (CETN's), to computer model documentation, to lengthy significant journal articles. Seven workshops have been held to periodically convey research results to the Corps field elements. Topics covered such aspects as measurement of wave direction and coastal engineering uses for radar, and they included "hands-on" training in the use of selected computer wave models. Feedback has generally been favorable, and it has helped to focus attention on the needs of the field offices.

Thus far in fiscal year 1985 achievements include completion of a draft Engineer Manual titled "Water Levels and Wave Heights for Coastal Engineering Design," completion of a technical report summarizing the shallow-water spectral form, publication of a report on deepwater wind wave growth with fetch and duration, and draft CETN's on directional wave spectra and on a wave model overview. Initial verification on a new shallow-water wave growth and propagation model was performed, and a literature review on wave height distributions was begun. Two workshops were held for Corps District and Division personnel on radar capabilities for waves and on shallow-water numerical wave modeling.

Future Plans

Research presently under way, or planned for the future, continues to focus on the Corps' wave estimation needs. The time-dependent shallow-water wave growth model is being improved both in its capabilities (for example, addition of swell to the model) and in its ease of use. Also this model will be adapted to handle hurricane wind fields, which present the complexity of rapidly turning winds, along with a small grid to resolve the storm details. The effect of a narrow fetch width on wave growth will be investigated to determine the appropriate modifications needed to model this situation with existing wave growth models. Work on shallow-water wave height distributions will continue, and the parameterization of swell spectra will begin in response to West Coast Corps needs. The work unit plans two field data collection efforts. During the DUCK '86 experiment, water surface elevations throughout the surf zone will be collected, and measurements of shallow-water fetch and duration limited wave growth will be collected for revision of the shallow-water design curves. Workshops will be periodically held to convey research results to Corps coastal engineers.

TMA SPECTRUM DEVELOPMENT

A more recent achievement of this work unit has been the development of a self-similar spectral shape for finite depth wind waves and the parameterization of this spectrum in terms of the wind speed, water depth, and peak spectral period. This development involved a cooperative effort between CERC researchers and scientists from two European laboratories.

Background

Phillips (1958) suggested that there was a region of the spectrum of wind generated deepwater gravity waves in which the wave energy density has an upper bound given in terms of frequency f by the expression

$$E_m(f) = \alpha g^2 f^{-5} (2\pi)^{-4} \tag{1}$$

where α is a constant. This region of the spectrum (to the high side of the single spectral peak) was called the equilibrium range (Figure 1), and the limit was thought to be a result of a limiting wave steepness at each frequency beyond which deepwater wave breaking would occur.

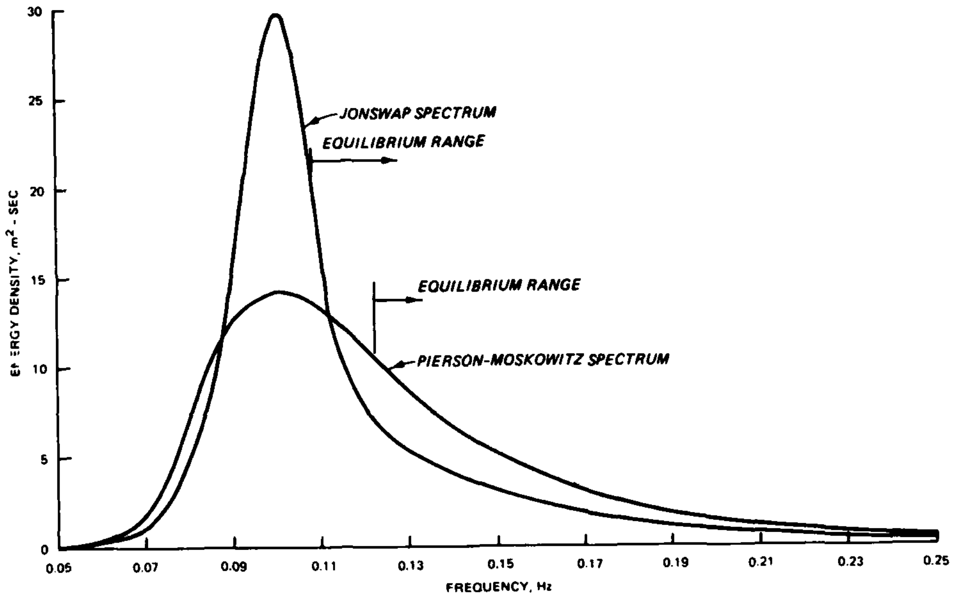


FIGURE 1. PIERSON-MOSKOWITZ AND JONSWAP SPECTRAL FORMS

A spectral shape for fully developed deepwater waves incorporating Phillip's equilibrium range was advanced by Pierson and Moskowitz (1964). It is expressed as

$$E_{pm}(f) = E_m(f) \cdot P(f, f_m) \tag{2}$$

where f_m is the frequency of the spectral peak, and P is a function that describes the forward face of the spectrum. A typical example of this deepwater spectrum is shown in Figure 1. The main drawbacks to Equation 2 are that the higher winds seldom hold steady long enough for full development to occur and that the fetch lengths over which the wind is blowing sometimes are not sufficient for full development.

Hasselmann, et al. (1973) extended Pierson and Moskowitz's development to include partially developed wave conditions by the addition of another factor:

$$E_j(f) = E_m(f) \cdot P(f,f_m) \cdot J(f,f_m,\gamma,\sigma) \tag{3}$$

Field data from the Joint North Sea Wave Program (JONSWAP) were used to parameterize the variables α, γ, σ, and f_m in terms of fetch length and the windspeed. The effect of this additional term is shown in Figure 1. Both spectra shown in Figure 1 contain the same total energy.

Kitaigorodskii, et al. (1975) examined the possibility that an equilibrium range for the spectrum also existed in finite depth water. Field observations led them to believe that the proper scaling was in wave number space and that it took the form of k^{-3}. Phillip's deepwater equilibrium range was modified by an appropriate factor to yield the finite depth equilibrium range given by:

$$E_m(f,h) = E_m(f) \cdot \phi(f,h) \tag{4}$$

where $\phi(f,h)$ varies monotonically from a value of one in deepwater to zero as the depth decreases, as shown in Figure 2.

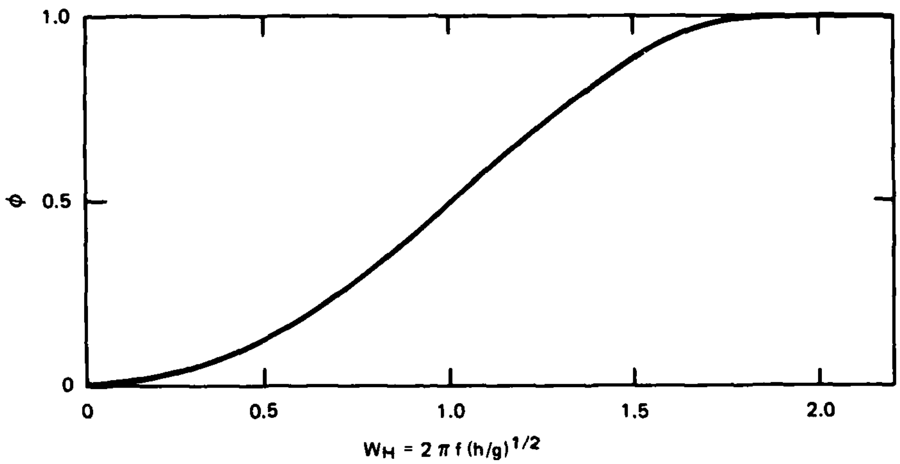


FIGURE 2. VARIATION OF ϕ WITH DIMENSIONLESS FREQUENCY

Spectral Form

A first approximation for a finite depth wind sea spectral shape was proposed by an international group of scientists, including Dr. C. L. Vincent of CERC (Bouws et al., 1985). They substituted the Kitaigorodskii et al.

(1975) finite depth equilibrium range (Equation 4) for Phillip's deepwater equilibrium range in the JONSWAP expression (Equation 3) to obtain the following:

$$E_{TMA}(f,h) = E_m(f) \cdot \phi(f,h) \cdot P(f,f_m) \cdot J(f,f_m,\gamma,\sigma) \tag{5}$$

Bouws et al. (1985) named this self-similar finite water depth spectral shape the TMA spectrum by combining the first three initials of the data sets used for field verification (Texel, MARSEN, and ARSLOE). Figure 3 illustrates the effect of decreasing depth when all other parameters are held constant. Parameterization of the variables α, γ, and σ in terms of water depth, windspeed, and peak spectral period was performed by fitting Equation 5 to over 2,800 wind sea spectra representing conditions with windspeeds ranging between 4 and 25 m/sec, bottom materials ranging from fine to coarse sands, bottom slopes ranging from 1:150 to nearly flat, and depths from about 5 to 45 m.

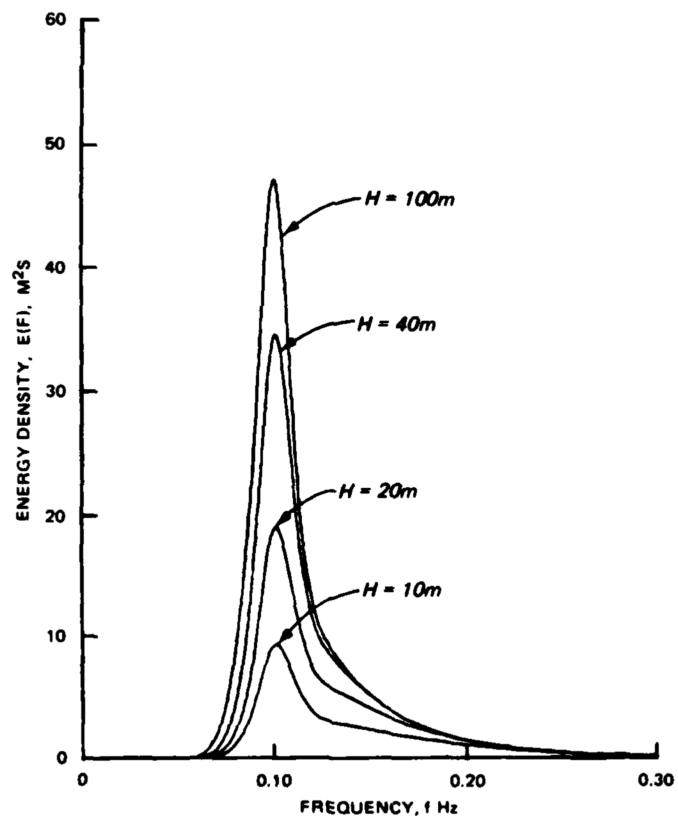


FIGURE 3. VARIATION OF TMA SPECTRUM WITH WATER DEPTH

They determined the following empirical expressions:

$$\alpha = 0.0078\kappa^{1/2} \tag{6}$$

$$\gamma = 2.47\kappa^{0.39} \tag{7}$$

$$\sigma = \begin{cases} 0.07 & f \le f_m \\ 0.09 & f > f_m \end{cases} \tag{8}$$

where (9)

$\kappa = 2\pi U^2/gL_m$

U = windspeed

L_m = wavelength associated with f_m from linear wave theory

Figure 4 shows the fit of the TMA spectra to field data.

Significant Wave Height

The maximum depth-limited energy-based significant wave height H_{mo} for any combination of depth, windspeed, and peak spectral period can be found using the following formula (Hughes, in press):

$$H_{mo} = \frac{1}{\pi} (\alpha)^{1/2} L_m \tag{10}$$

Values of α are found using Equation 6, and L_m is determined from linear wave theory for the peak period. This simple result has proven to be a useful upper limit for the energy-based H_{mo} in pure wind seas.

The significant wave height for wind seas can be transformed also from one site to another site using the following expression:

$$\frac{H_{mo_1}}{H_{mo_2}} = \left(\frac{L_{m_1}}{L_{m_2}}\right)^{3/4} \tag{11}$$

under the restrictive assumptions that the windspeed is the same at both sites and that no wave refraction or diffraction occurs between sites. It is usually assumed that the peak spectral period remains constant. Figure 5 presents significant wave heights that have been transformed from WIS Phase III hindcast data available in 10-m depth to a gage site located in 3.4-m depth.

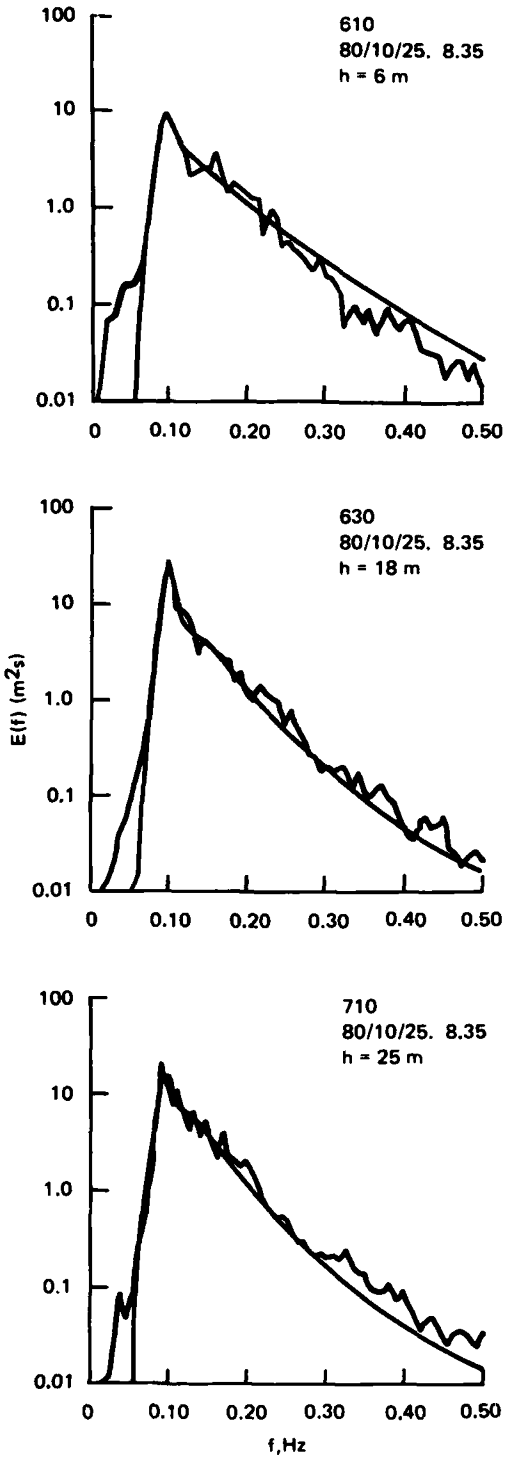


FIGURE 4. TMA SPECTRA FIT TO FIELD DATA FROM ARSLOE

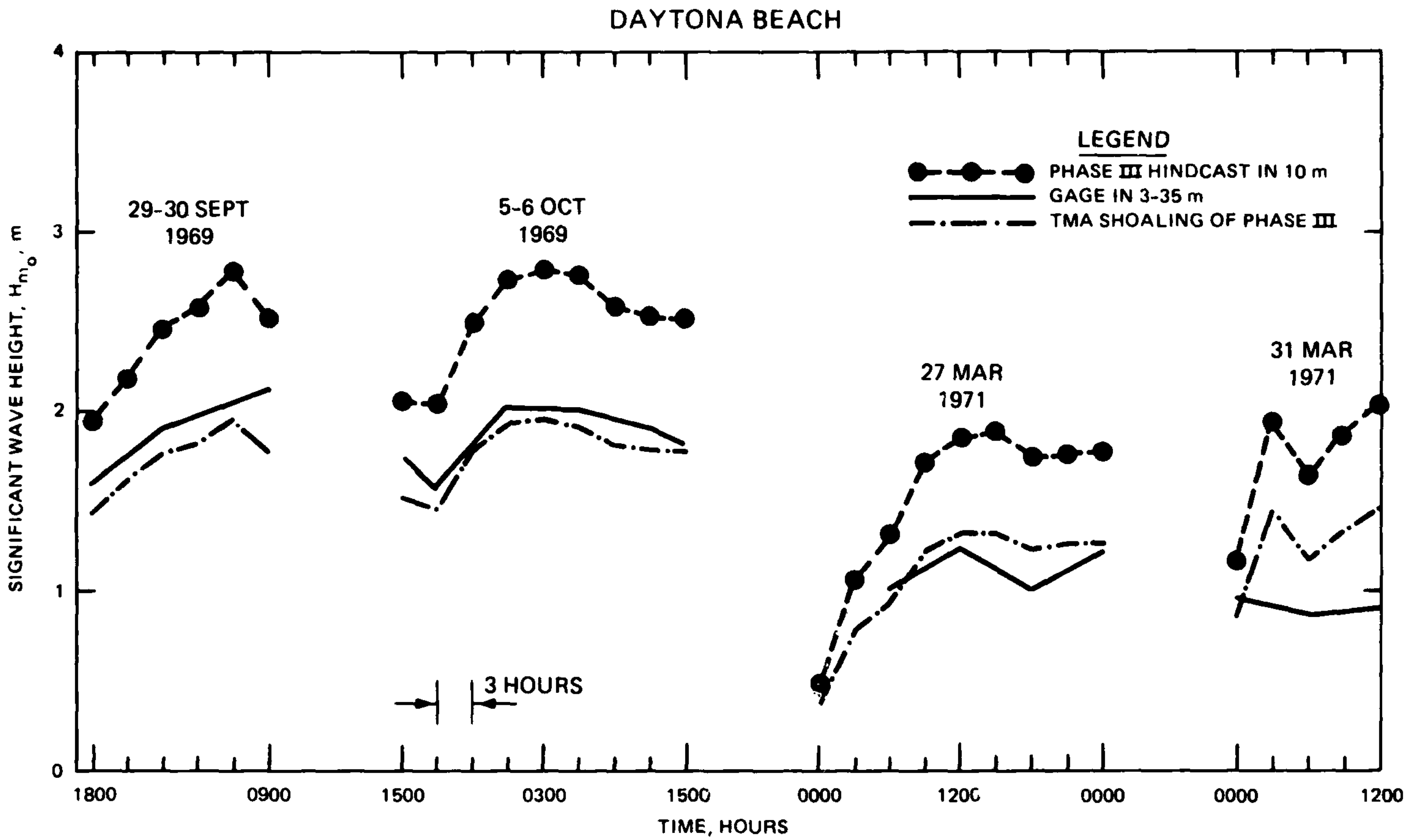


FIGURE 5. SHOALING OF HINDCAST DATA USING EQUATION 11

Only those data representing single-peaked wind seas were transformed. The comparison to gage data is encouraging.

Nonrefracted, depth-limited wave estimates in terms of deepwater significant wave heights also can be made using Equation 11. Figure 6 gives nondimensional wave height versus relative depth using the TMA derived relationship. In Figure 6, H_0' is unrefracted deepwater wave height, and L_0 is deepwater wavelength. Included in the figure is nonrefracted linear wave theory which has been shown to predict the shoaling of long-crested narrow-banded swell spectra reasonably well. The departure of the two theories has significant consequences for the design engineer. Using linear theory to shoal wind sea significant wave heights can result in an unnecessarily large design wave height and perhaps costly overdesign. Conversely, using the TMA relationships for conditions other than single-peaked local wind seas could result in an inadequate design. Additionally, design criteria developed based on monochromatic wave model testing may be conservative for wind seas, although this cannot be proven until results from irregular wave model testing become available. Figure 6 helps to underscore the urgent need for irregular wave design criteria along with the need to formulate a unifying theory for both wind sea and swell.

Conclusion

The TMA spectrum is a useful finite-depth spectral form for obtaining depth-limited spectral wave estimates for use in design; and, while not the final answer, it provides at least suitable interim guidance for the case of wind seas.

PHOTO-POLE EXPERIMENT

A planned endeavor of "Wave Estimation for Design" is participation in a novel data gathering exercise at CERC's Field Research Facility during the DUCK '86 experiment. The purpose of the photo-pole experiment is to film the water surface elevation relative to stationary, vertical poles placed on a transect through the surf zone. As many as 50 poles will be placed on the line, and 16mm cameras will synchronously film the water elevations on these poles. Filming of the poles will be from scaffolding on the beach at an elevation of about 4 m. The elevation is necessary to ensure that waves in the foreground do not obscure the poles and to eliminate the horizon from the film images.

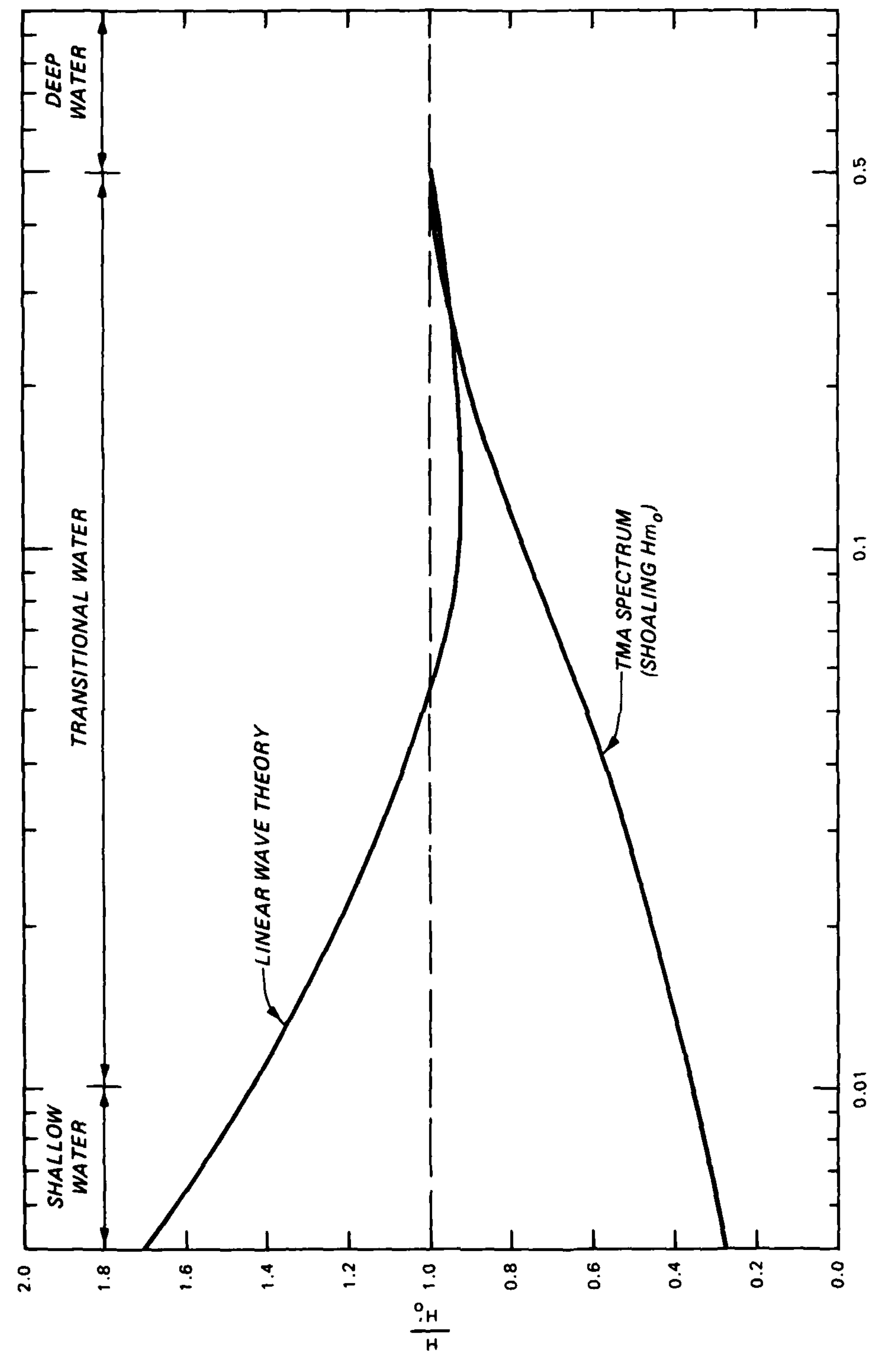


FIGURE 6. UNREFRACTED SHOALING VERSUS RELATIVE DEPTH

This project is a joint effort with the Coastal Processes Branch, CERC, and it involves a total of four researchers and two work units. The planned experiment is an outgrowth of Dr. Nicholas C. Kraus's experiences in Japan before he joined CERC, and it is intended to bridge an existing research gap by (1) obtaining quality surf zone wave and water level prototype data, and (2) developing a new measurement technique for use in the surf zone.

Actually, the filming of waves as they pass stationary poles is not a new concept. Besides the work done in Japan (Hotta and Mizuguchi, 1980), several investigators in the United States have had experience with similar filming techniques, including Dr. Lee Weishar of CERC.

However, the photo-pole method has one major drawback, analysis of the film record. No meaningful use can be made of the 16mm films until the water levels on the poles are converted to numerical values for entry into a digital computer. This typically involves a manual or semiautomatic procedure which is labor intensive and, consequently, costly. For example, the Japanese display each frame of the 16mm film upon a digitizing table, and the operator moves the "mouse" to the position where the pole intersects the water level. The operator then triggers the taking of the data point and progresses to the next frame (Dr. N. Kraus, personal communication). The effort required to digitize 3,000 frames (a 10-min wave record at 5 frames per sec) using this semiautomatic technique rapidly becomes tedious.

Automatic Film Analysis

The primary contribution to the photo-pole experiment by this work unit is the development of a technique to fully automate the analysis of the 16mm films. This will be accomplished using CERC's 16mm film image digitizer.

By using highly reflective paint and a proper selection of lens filters, the photo-poles can be made highly visible while the glare off the water is reduced. The objective is to get the greatest contrast between the poles and the water. This contrast is necessary for the unattended sensing of the water surface relative to the poles using the image digitizer.

The planned analysis procedure is best explained by example. A roll of developed 16mm film is placed on the system's programmable film transport and advanced to the desired starting point. Figure 7 shows a typical frame as loaded on the machine. Note that the image is rotated clockwise 90 deg and that the top of the pole points toward the right of the figure. The image can be scanned from top to bottom in Figure 7 by a horizontal, light-sensitive

FIGURE 7. PHOTO-POLE FRAME AS MOUNTED IN DIGITIZER

diode array. Image resolution is 2,048 X 2,048 pixels. The first task is an operator-assisted calibration. The two rods that are welded on the photo-pole in Figure 7 serve as calibration marks. The operator moves the scanning array until the monitor indicates the scan line is reading a section through the rods. Figure 8 is an actual photograph of the intensity return from a section through the calibration rods. The two spikes indicate the positions of the rods which reflect more light than the water in the background. The software can determine the pixel locations of the spikes; and knowing the distance between the rods in millimeters, a calibration factor in millimeters/pixels is obtained. The procedure is repeated for up to four poles on the single frame, and it is done only once for each roll of film. Performing the calibration this way allows multiple poles in each frame and helps to minimize geometric distortions due to camera angles and lens.

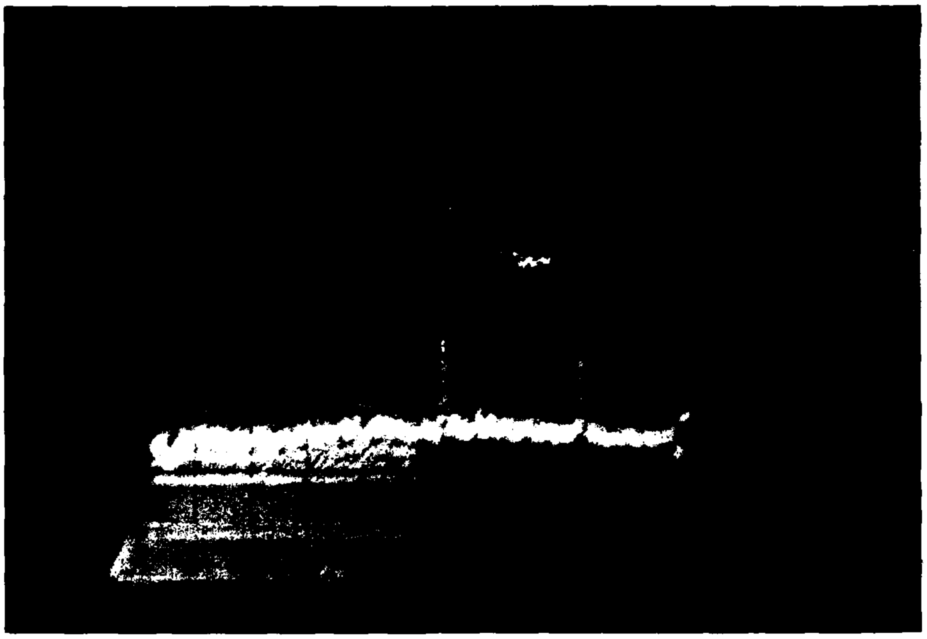


FIGURE 8. SCAN THROUGH CALIBRATION RODS OF POLE (shown in Figure 7)

After calibration, the software takes over and sequences through the film determining the water level on each of the poles in the frame. Figure 9 shows an actual scan through a photo-pole. The region of high intensity is the pole, and the low intensity is the water. The position of the water level

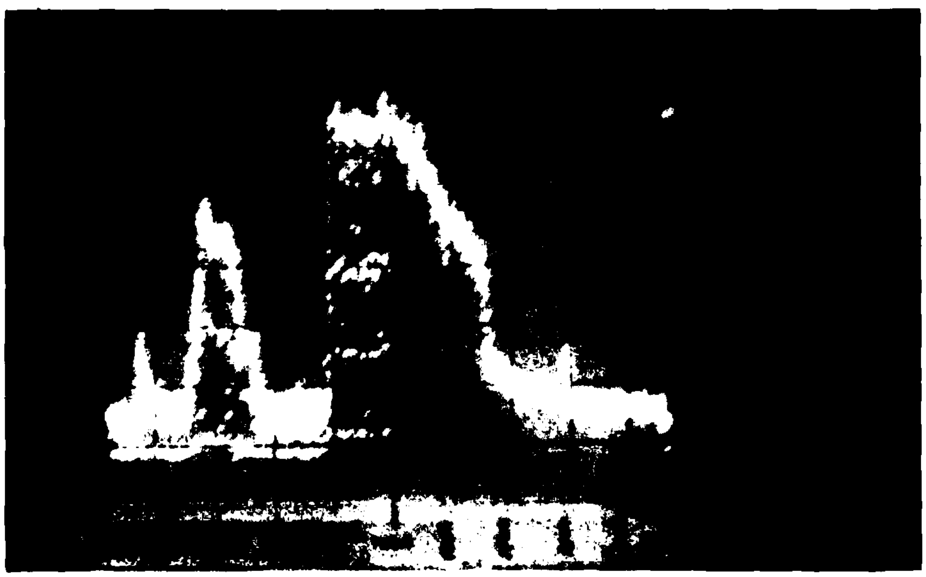


FIGURE 9. SCAN THROUGH PHOTO-POLE (shown in Figure 7)

on the pole (large step increase on the left side of Figure 9) is easily determined by the software, and the value is converted to millimeters relative to a calibration rod and written to mass storage. Note in Figure 9 that the intensity of the light reflected from the pole has a slope caused by the pole not being exactly vertical.

A potential problem is anticipated when resolving the water level in the presence of white water. Figure 10 illustrates the decreased definition caused by white water. This problem will be attacked by, first, trying to lessen the reflection of the white water using filters and, second, by having the software flag points which have a given level of uncertainty associated with them. When necessary, these questionable data can be edited by examination of the visual record. The ultimate goal is to process a frame with four poles every 10 sec in an unattended mode.

Benefits

The ability to automatically analyze photo-pole 16mm films will allow the collection of a large amount of surf zone water elevation data by the direct measuring of the surface elevation. This will support investigations into surf zone spectra, wave transformations in the surf zone, and surf zone wave height distributions. Knowledge gained from these investigations will ultimately lead to improved design criteria and design guidance in this least understood realm of coastal hydraulics.

The filming technique has the following advantages:

(1) It is easy to use.

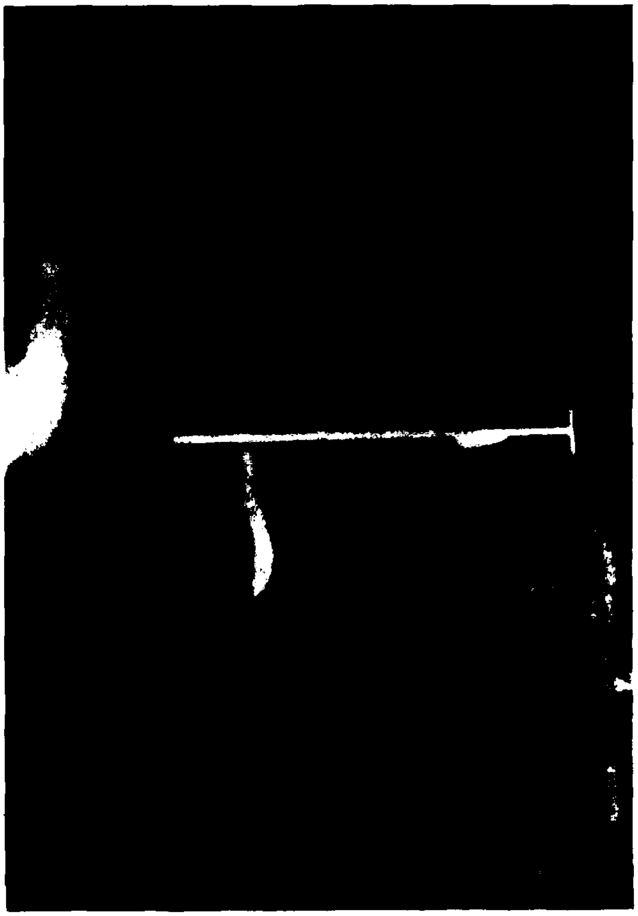
(2) It is relatively inexpensive.

(3) No valuable equipment is placed in the water.

(4) A permanent visual record is created for later referral.

(5) Analysis will be performed using existing equipment.

The filming technique has potential application in the testing of subsurface-mounted wave measuring systems because it actually records the "true" elevation rather than surmising the elevation through a mathematical transform. Additionally, the experience gained with the cameras and the image digitizer during the course of this experiment may be adapted to other research areas such as laboratory applications.



a. Photo pole with white water present

b. Scan through photo-pole

FIGURE 10. SCAN THROUGH PHOTO POLE WITH WHITE WATER PRESENT

SUMMARY

The work unit "Wave Estimation for Design" continues to pursue its objective of providing engineering solutions to wave estimation problems relating to the design, construction, operation, and maintenance of coastal projects. Considerable progress has been made toward this goal by the researchers who have worked in this work unit, and timely transfer to Corps field offices of new techniques for wave estimation has been achieved through periodic workshops.

A recent development, the TMA spectrum, was presented in more detail to illustrate shallow-water wave estimation using a parameterized spectrum. Differences between linear wave theory shoaling and TMA shoaling can become quite large, pointing out the basic difference between swell waves and wind seas.

A different research avenue is highlighted by the planned photo-pole experiment. This cooperative effort will provide quality surf zone water elevation data for use in improving predictive capability in the surf zone. Automatic film analysis will overcome the main drawback of the filming technique, and it may open up new applications in the future.

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DISCUSSION

PROF. WIEGEL: *With respect to the shallow-water spectrum, what's the status of all the work that Omar Shemdin has done on some of the physical processes of energy losses? He has also done a lot of work on wave-wave interactions, and I didn't see any mention of it. I think a lot of it was done for CERC.*

DR. HUGHES: Yes, we have procured a model from Shemdin which includes all the source terms as he see them. Right now there are two theaters of thought with regard to spectral evolution. One strongly supports Hasselmann's nonlinear wave-wave interactions. Another group feels the bottom friction is very important.

PROF. WIEGEL: *Well, can't you have both? I don't see why there are two schools of thought.*

DR. HUGHES: Well, you can have both, but some of the more recent work of Kitaigorodskii in 1983 says that nonlinear wave-wave interactions are most important. One problem we've had with the bottom friction is having to use unrealistically high coefficients of friction in order to get the attenuation that the data show.

PROF. WIEGEL: Thirty years ago Professor Einstein got some mud out of San Francisco Bay, the north end, because they were looking at the waves there. The generation was very low compared with what one expected. He brought a series of 55-gal drums of mud and put the mud in the tank and then generated mechanical waves in the system which in turn generated waves in the mud. And then damping occurred. It was not friction as hydraulic engineers think of friction; it was the damping in the mud. Now geotechnical people have been doing a lot of work since then but not on that particular thing. When you have a foundation problem and a vibration of an offshore oil structure, for example, or a tower with wind loads or earthquake loads, you look at the amount of energy that is damped. The way that energy is damped through the geotechnical things is very substantial. So we're not talking necessarily about bottom friction, per se. We've got friction, as we think of it rough in the sand grades, and it is the geometric friction, which of course we do on river material. And then there's the energy loss due to the fact that some bottoms are porous. The bottom is sand, and you can have a level of energy loss through porosity, the forcing of flows through the porous bottom. There's a whole series of mechanisms.

DR. HUGHES: Yes.

PROF. WIEGEL: I've never heard before that there are two fields of thought. I think there should be only one field of thought and that many of these mechanisms are occurring simultaneously.

DR. HUGHES: That's absolutely right. There are lots of different mechanisms.

One of the results from the group that Dr. Vincent was in was that they saw no systematic variation due to bottom friction in the work that they did, and they had 2,800 spectra, over a wide variety of bottom conditions from very course to very fine. Now I agree with you there is a viscoelastic effect when you have a very muddy bottom, and this is something that CERC will probably look into; I think you're going to hear some more about that during the open public comment during the meeting.

DR. LE MÉHAUTÉ: I think what Professor Wiegel has been referring to has been very thoroughly investigated by Dr. Yamamoto. The results of Dr. Yamamoto's study indicate that the damping coefficient is the function of the soil characteristics. In the past, we used a soil which was a nonmovable skeleton, in which case the porosity and the terminal friction by boundary layers were only to be considered. Dr. Yamamoto has demonstrated that the damping due by particle/particle interaction friction between sand particles is also a mechanism for damping which is particularly important, for example, at the delta of the Mississippi River. It's not so important on the continental shelf on the east coast of the United States which is more of a sandy nature. So this problem has been very thoroughly investigated over the last 2 years.

I did a theory for this kind of damping for paralytic waves--explosion generated waves as a matter of fact--and I found that it is an important mechanism also in some soil for explosion generated waves, but the damping by turbulent boundary layers also has been investigated by Drs. Ole Madsen and Grant. And they found friction coefficients which are indeed fairly high which would explain the damping of swell, for example, such as it is observed.

I don't think that the problem is resolved. I don't think that we can justly conclude one or the other, as you say. It needs more investigation, but I don't think that at this time we can conclude that the friction coefficient which is used for explaining the damping of what has been observed is too high. We need to have further investigation.

DR. HUGHES: Yes. That's ongoing as funds allow us to look into the various source and sink mechanisms in the spectral generation and evolution. We do maintain both the Shemdin model and a model developed by Don Resio. Those are essentially the two schools of thought as to what the very dominant spectral sink term is, and we're looking into it. I agree that for swell spectra I see the friction is probably the overriding damping.

PROF. WIEGEL: *What do you call it, wave pole?*

DR. HUGHES: Photo pole.

PROF. WIEGEL: *Photo pole. Chris Carlson did a fair number of studies, and he used more brute force at the start. He used the SRI system which is at least one step in the right direction, and a fair amount of the software for the photogrammetry was developed as a part of it. Have you looked at that? I know that he did it. I can't remember the details, but he had four or five poles in there and was getting data off all of them and calculating spectra at different positions to see the spectra change through the surf zone.*

DR. HUGHES: Yes, I've read his paper which was delivered at the Houston conference. I haven't read his full report.

PROF. WIEGEL: There is a copy here because one was sent here, including the full thesis with all the details.

DR. HUGHES: Some of Carlson's methods can be adopted; however, a lot of it is equipment specific as to what we can and cannot do.

PROF. WIEGEL: You might look at it and at the computer programs for taking care of the photogrammetric problems also.

DR. HUGHES: Yes.

DR. LE MÉHAUTÉ: *I see that you have a program of measurements for the shallow-water spectrum. May I ask you where you intend to make this kind of measurement?*

DR. HUGHES: That decision hasn't been made yet. What we need to do first is to survey existing measurements and find out what data were lacking in order to develop some good shallow-water fetch and duration limited methods, engineering methods. Once we can identify the gaps, we can pick an appropriate site. The bay behind the Field Research Facility (FRF) would be a good nominee because it's shallow. I understand it has a fairly flat bottom, and since it's close to our FRF we've got good support.

DR. LE MÉHAUTÉ: I just want to mention that Biscayne Bay, which is about 15 miles long and 5 miles wide, also has a very uniform depth at around 10 ft. It also has a nice level to work on shallow-water methods.

DR. HUGHES: Your point is well taken. That's several years in the future. Planning will probably begin on it late next year.

NEARSHORE WAVES AND CURRENTS

CERB Proceedings

Dr. Jon M. Hubertz
Oceanographer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

Measurements of nearshore waves and currents at the Coastal Engineering Research Center's Field Research Facility (FRF) show that the wind can be a force equal to that of breaking waves in generating longshore currents. Time series measurements of longshore current show a direct response to the wind. A nearshore current modeling system has been developed which employs a directional spectral wave model to supply the radiation stress field to a nearshore circulation model. Such an approach removes the need to specify breaker height, angle, position, and mechanisms such as lateral shear stress to obtain agreement with measurements of longshore currents. The model has been used to hindcast wave-driven currents at the FRF. Results are presented. Also, two improvements for estimating nearshore currents are suggested.

INTRODUCTION

Improvements are needed in the technique presently used to estimate nearshore currents. These techniques, summarized in the Shore Protection Manual (SPM) (1984), "are based on the assumption that the major currents in the littoral zone are wave induced...." The techniques assume monochromatic, unidirectional waves to estimate longshore current speed. It is assumed that "longshore currents are restricted mainly between the zone of breaking waves and the shoreline" (SPM 1984).

Measurements of nearshore currents made at the Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) show that longshore currents equal to or larger than expected from wave effects can be present throughout the water column, far removed from the breaker zone, in depths of at least 6.5 m. These currents may have components attributable to the wind, tide, and circulational features larger than the local scale in addition to a wave-induced component. Any one of these may dominate at a given site and time.

The objective of the "Nearshore Waves and Currents" work unit is to develop methods of predicting nearshore currents resulting from meteorological and astronomical processes. The mean currents resulting from these processes in shallow water provide, in many instances, the major mechanism for the transport of sediment, pollutants, and other constituents in shallow coastal waters.

NEARSHORE CURRENT MODELING

An annotated bibliography and state-of-knowledge report titled "Surf Zone Currents" was published by Basco (1982). The state-of-knowledge report was used as a starting point for discussions about the theory, modeling, and measurement of nearshore currents. These discussions by experts within and outside of the Corps of Engineers (CORPS) were carried out in a workshop held at the University of Delaware in June 1982. A summary of the results was published by Hubertz (1983).

In the discussions of nearshore current modeling in the SPM (1984), it was concluded that

> numerical models exist today which give acceptable qualitative answers to simple situations, but improvements can be made in a number of areas. The improvements most needed in application oriented models are as follows:
>
> (1) Computation of the wave climate in the interior of the grid, which would include refraction, shoaling, diffraction, reflection, dissipation, and wave-current interaction.
>
> (2) Incorporation into models of wave-breaking.
>
> (3) Parameterization of turbulence in models.
>
> (4) Incorporation into models of surf zone energy dissipation.
>
> (5) Methods to specify waves and currents on the boundaries of the grid.
>
> (6) Incorporation into models of frictional processes.
>
> (7) Methods for modeling periodic wave input.
>
> (8) Methods for modeling spectral wave input.
>
> (9) Methods for modeling complex bottom topography and structures.
>
> (10) Three-dimensionality.
>
> (11) Time-dependency.

Work under the modeling task in the "Nearshore Waves and Currents" work unit has concentrated on incorporating items 1, 2, 4, 6, 8, and 9 in a nearshore current model. Items 10 and 11 will be investigated after a two-dimensional steady state model has been satisfactorily verified.

Preliminary verification of a nearshore current model has been made using data from the "DUCK '82" experiment. This work was presented at the 19th International Conference on Coastal Engineering (Hubertz, in press) and is published in the proceedings. It is apparent from that investigation that nonwave-induced currents can be an important component in the total nearshore current vector.

Nearshore current data collected as part of the Field Data Collection Program at the FRF show that longshore currents of the same order of magnitude as wave-driven longshore currents are generated by the wind. Wind stress forcing has been included in the nearshore current model, and verification is beginning. Measurements of wind stress are planned as part of the field measurement task of the work unit to verify existing wind stress relationships in a coastal area. Examples of the wind effect on longshore currents are shown in the section on wind effects.

Nearshore waves, currents, and winds are the primary variables to be measured in the fall of 1985-1986 at the FRF. The measurements are planned so that the resulting data will provide a description of nearshore currents within a one-half square kilometer area. Horizontal, vertical, and temporal definition of currents will result if the measurements are successful. The resulting data will be used to extend our knowledge of nearshore waves and currents and verify techniques for predicting the same. After analysis and reporting of the field measurements, work will begin on modeling the nearshore region in three dimensions.

ASPECTS OF MODELING SYSTEM

The nearshore current modeling system consists of (1) a shallow-water directional spectral wave transformation model, (2) an algorithm to calculate the three components of radiation stress using the three-dimensional wave spectra, and (3) a two-dimensional long wave equation current model in part driven by the radiation stress components.

Wave Model

The wave model computes over two horizontal dimensions and allows two-dimensional variation of depth. It is a steady state model which balances spectral energy considering the effects of advection, refraction, shoaling, atmospheric input, bottom friction, percolation, and nonlinear wave interactions. In addition to these terms, a limitation on wave energy in shallow water has been imposed via a depth and frequency dependent factor ϕ suggested by Kitaigorodskii et al. (1975). In very shallow water, the spectrum is further modified by the factor $\exp[-\beta(f/f_m)]$ where β is a shape factor, f the frequency, and f_m the peak frequency. This has been used in only a few cases using data from the FRF, but with good results. More work needs to be done to determine if such a factor is appropriate and the sensitivity of β to various wave and beach conditions.

This model is based on physical principles, empirical data, and assumptions which simplify the problem enough to make it solvable. Those processes which are considered most important in the propagation and transformation of waves in shallow water are included in the model. The important fact that waves are limited in energy and frequency distribution in shallow water is represented in the model. Thus, one no longer has to rely on a monochromatic, unidirectional approach or specify breaking criteria to calculate the distribution of wave energy nearshore.

Radiation Stresses

A conclusion of the Nearshore Currents Workshop was that the theory of radiation stresses (Longuet-Higgins et al., 1964), provides a simple and valid mechanism for the generation of nearshore wave-driven currents. However, such a mechanism is only as accurate as the wave energy distribution from which it is derived. The present technique for calculation of longshore currents recommended in the SPM (1984) requires specification of beach slope, breaker height, angle, and mixing coefficient. For situations such as unidirectional swell with a well-defined breaker line, this technique gives acceptable results. For those cases of multifrequency direction waves breaking over a wide area nearshore, breaker height, angle, and location become ill-defined; and estimates of longshore current using this technique are inaccurate.

In the present approach, the radiation stress components are calculated by integrating the expressions for these components over frequency and direction. In this way, all waves and directions are included. This approach reduces to the monochromatic result when a single frequency direction wave is input. No input of beach slope, breaker height, angle, or mixing coefficient is required. The radiation stress field in a nearshore two-dimensional area is specified directly from the three-dimensional wave spectrum in the two-dimensional area. This stress field is then used to drive a two-dimensional current model.

Current Model

The current model is based on the long wave model of Butler (1980) modified by Vemulakonda et al. (1982) and Hubertz (in press). It is a time-dependent, two-dimensional, vertically integrated, implicit, finite-difference model. It includes terms for advection, surface deformation, bottom, wind, radiation, and lateral shear stress. It is presently being driven by winds or waves, or both, with the input held constant until a steady state is reached. Model hindcast results are compared with data collected at the FRF to illustrate model performance.

Model Simulation

A set of wave and current observations in the nearshore zone were obtained in the fall of 1982 at CERC's FRF in cooperation with the United States Geological Survey (USGS). These data were obtained along a line normal to shore and 457 m north of the FRF pier. The nearshore region modeled and the location of wave and current observations in relation to the pier location are shown in Figure 1. Measurements were made with three electromagnetic current meters and a pressure sensor mounted on a sea sled which was pulled to various positions along the profile line shown in Figure 1. The three current meters were mounted 0.54, 0.99, and 1.74 m from the seabed. Mean values of longshore and cross-shore flow over 34.1-min intervals were measured at various distances from shore. Estimates of significant wave height were made also using the current data and pressure data independently.

On 12 October 1982 waves at the pier end were measured with a significant height of 3 m and peak period of 15 sec. Such long period waves are extremely unusual on the US east coast. Wave and current measurements were made along the profile line and are shown in Figure 2. Longshore flow is northward in response to waves and winds from the southeast quadrant. The average magnitude from the measured values is about 27 cm/sec. Values are uniform with distance from the shore out to the last measurement station 285 m from shore.

The spectral wave model was run using a narrow spectrum which matched the significant height, peak period, and mean direction measured off the end

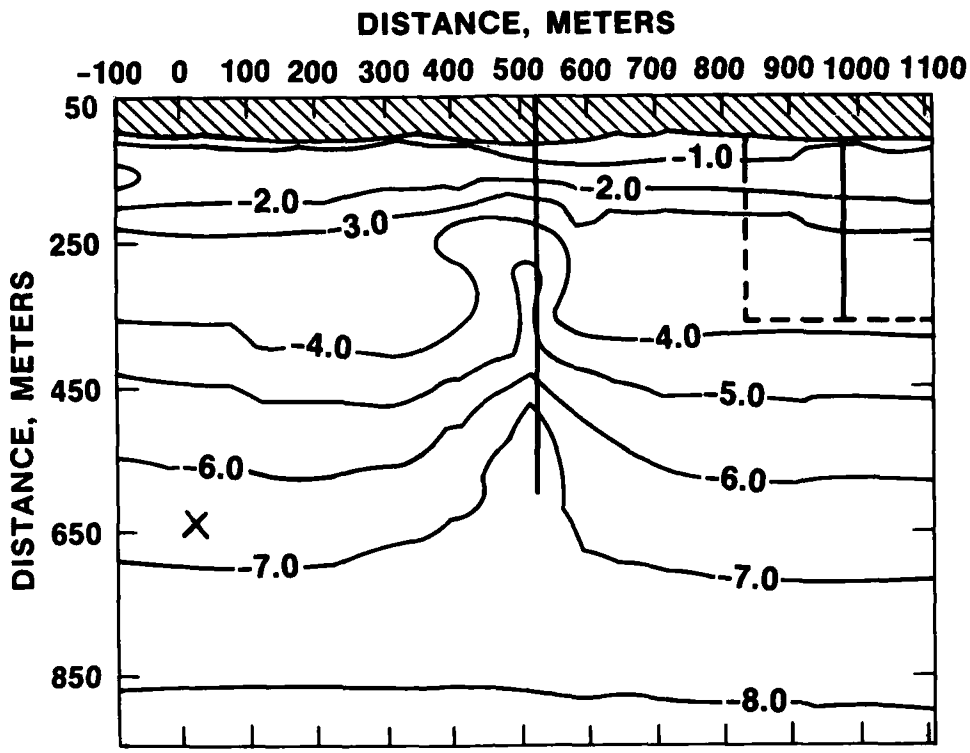

FIGURE 1. LOCATION OF THE MODELED REGION (DASHED LINE) IN RELATION TO THE FRF PIER (SOLID LINE OVER TROUGH) (Wave and current measurements made along solid line in model region; X denotes long-term current measurements begun in 1983)

of the pier. The results are shown in Figure 3. There is good comparison between observed significant wave height and calculated values with a rather uniform decrease in wave height from 2.5 m at the offshore station to 1 m nearshore. The longshore component of flow produced by the current model for this wave height distribution and no wind is shown in Figure 4. There is good correlation between measurements and model results leading one to assume that the longshore flow in this case is primarily wave-driven.

Note that this longshore flow profile is not typical of theoretical profiles which increase from shore to a maximum inside the "breaker line" and then decrease to zero seaward in a distance about the same as from shore to the "breaker line." The more uniform distribution of longshore flow with distance from shore, as measured and calculated here, is attributed to the uniform decrease in wave height toward shore as observed and modeled. The breaker zone in this case extended throughout the region of measurements (over

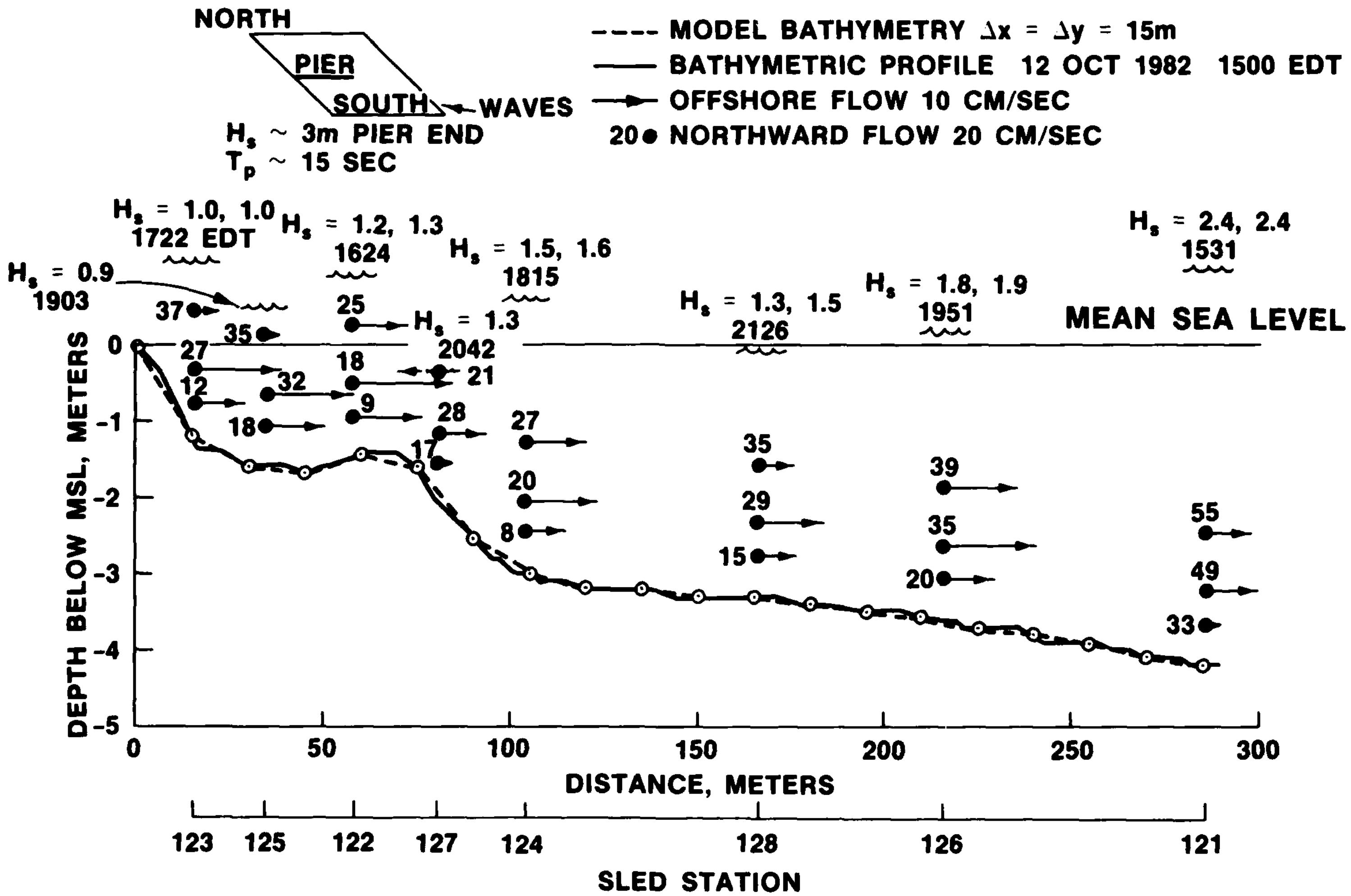

FIGURE 2. SUMMARY OF MEAN VALUES OF WAVE AND CURRENT DATA MEASURED ALONG THE PROFILE LINE AT THE FRF FOR 12 OCTOBER 1982

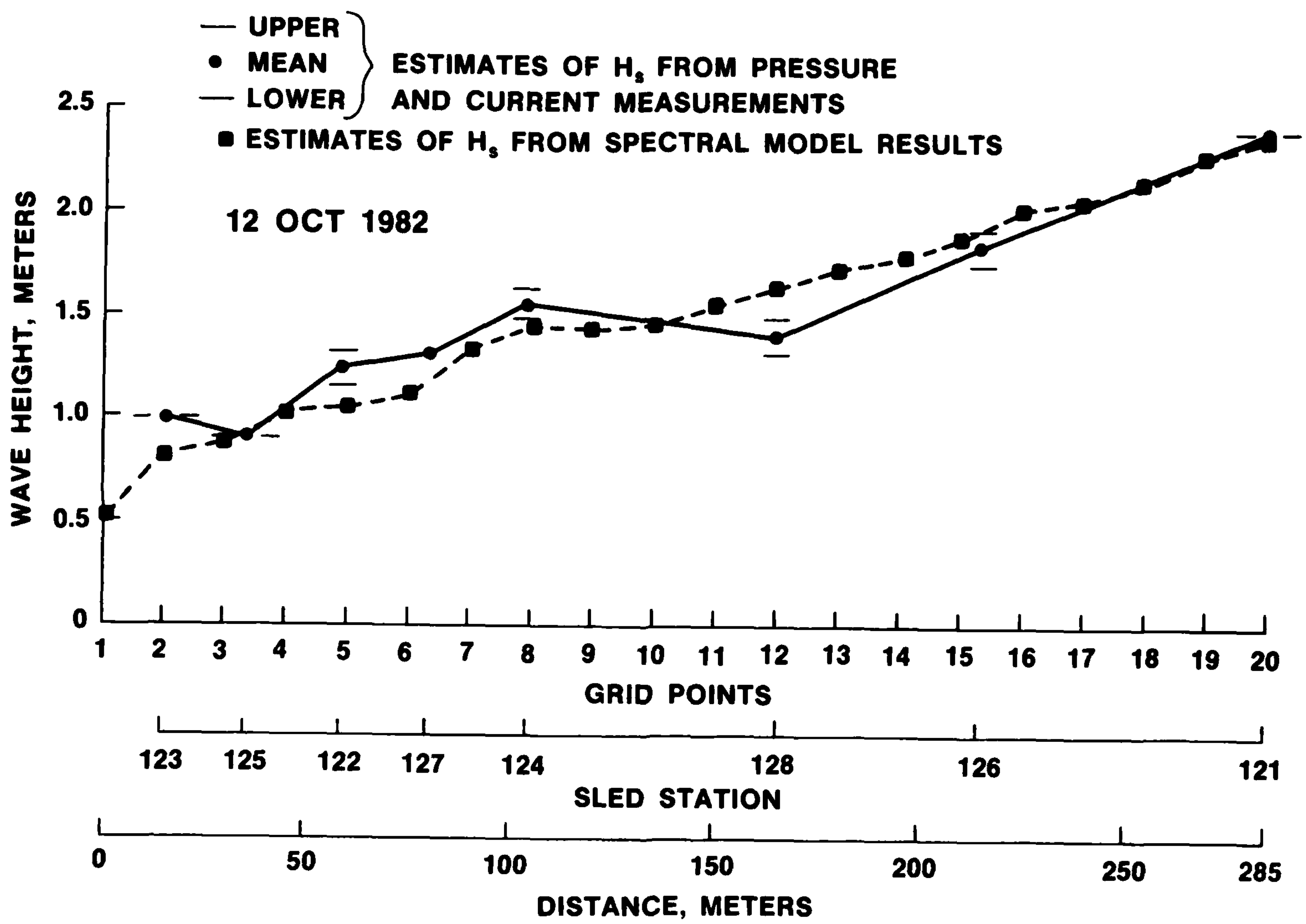

FIGURE 3. MEASURED AND CALCULATED VALUES OF SIGNIFICANT WAVE HEIGHT ALONG THE PROFILE LINE AT THE FRF FOR 12 OCTOBER 1982

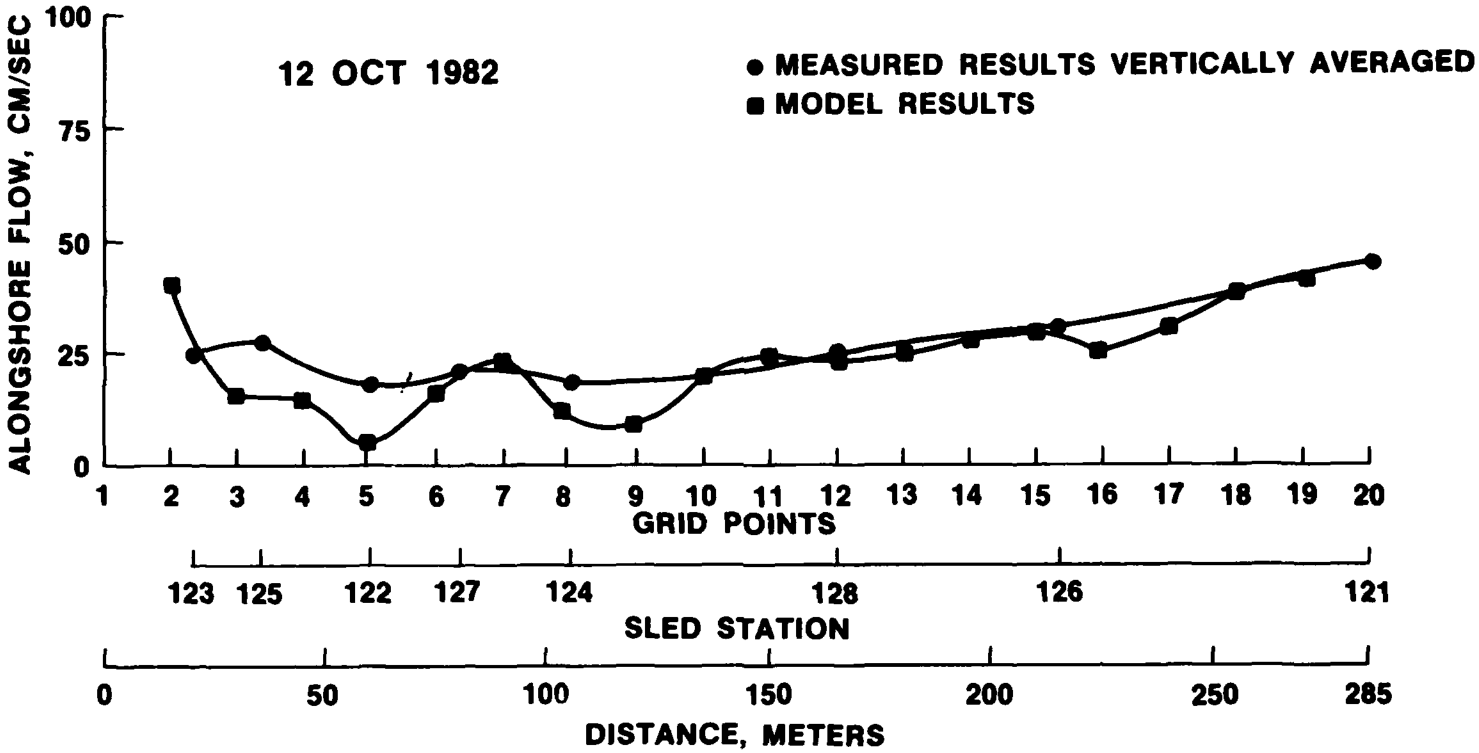

FIGURE 4. MEASURED LONGSHORE CURRENT ALONG THE PROFILE LINE AT THE FRF FOR 12 OCTOBER 1982

300 m) so that even for this case of swell there is no well-defined breaker height or line to use in the SPM technique.

WIND EFFECTS

Electromagnetic current meter measurements have been made since January 1983 at a point about 500 m south of the end of the FRF pier at a depth of 4.5 m in 6.5 m of water. The measurement series is not continuous, with rather large gaps in the record primarily in the winter months due to instrument or mooring problems. These measurements show the characteristics of the nearshore current at this point and indicate a direct relationship between the wind and nearshore current.

A total of 1,454 observations of longshore current is shown in Figure 5. They are in chronological order, but gaps in the record have not been included. Most values lie within the range of +30 to -40 cm/sec. A negative value indicates flow parallel to shore in a southerly direction. More observations show southerly flow than northerly. The average of all observations

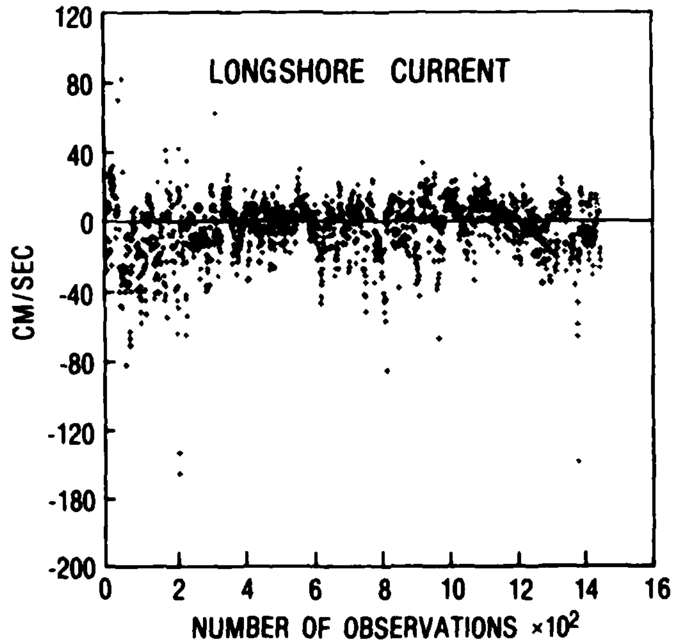

FIGURE 5. CURRENT METER MEASUREMENTS OF LONGSHORE CURRENT AT 6-HR INTERVALS (4.5-M DEPTH), 500 M SOUTH OF THE FRF PIER END DURING THE PERIOD FEBRUARY 1983 TO AUGUST 1984 (Not continuous in time)

is -5 cm/sec with the largest negative values in the fall, winter, and spring months. October and December are poorly represented, and no data are available in November and December. Most of the largest values, some as high as 150 cm/sec, are negative and occur in the fall through spring.

A similar plot for the cross-shore component is shown in Figure 6. Most values lie in the range of +10 to -10 cm/sec where negative values indicate flow onshore. The average of all values is 0 with no apparent bias for flow on or offshore.

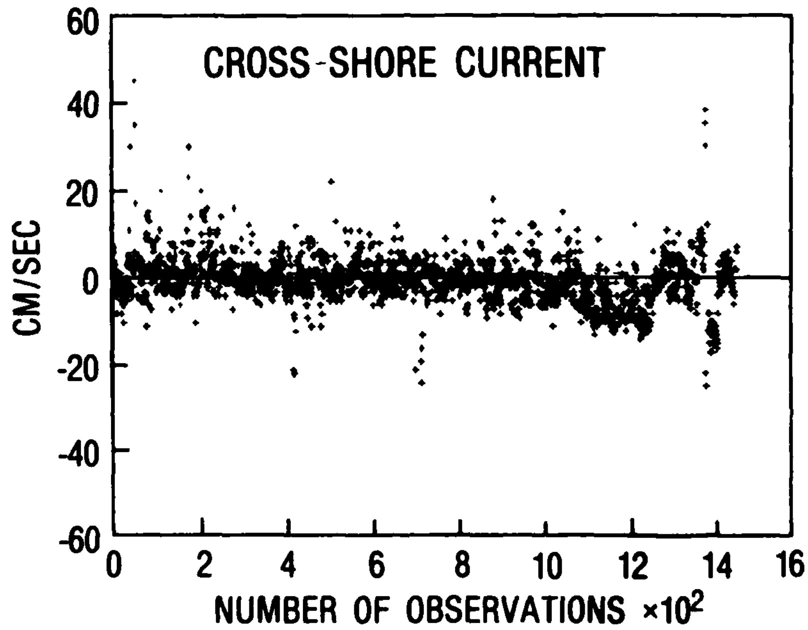

FIGURE 6. CURRENT METER MEASUREMENTS OF CROSS-SHORE CURRENT AT 6-HR INTERVALS (4.5-M DEPTH), 500 M SOUTH OF THE FRF PIER END DURING THE PERIOD FEBRUARY 1983 TO AUGUST 1984 (Not continuous in time)

There are two long periods of continuous data, one from February through May 1983 and the other from May through August 1984. Simultaneous measurements of wind speed and direction from the FRF building are available for the latter period. A spectrum of the longshore current component for the 1984 time series is shown in Figure 7. Three peaks of increasing magnitude and period are present at approximate periods of 12.5 hr, 1 day, and 1 week. The signal at 12.5 hr is attributed to tidal forcing. The other two signals appear to be weather related. One possibility for the daily cycle is the land sea breeze effect present in the summer months. The broader peak near a

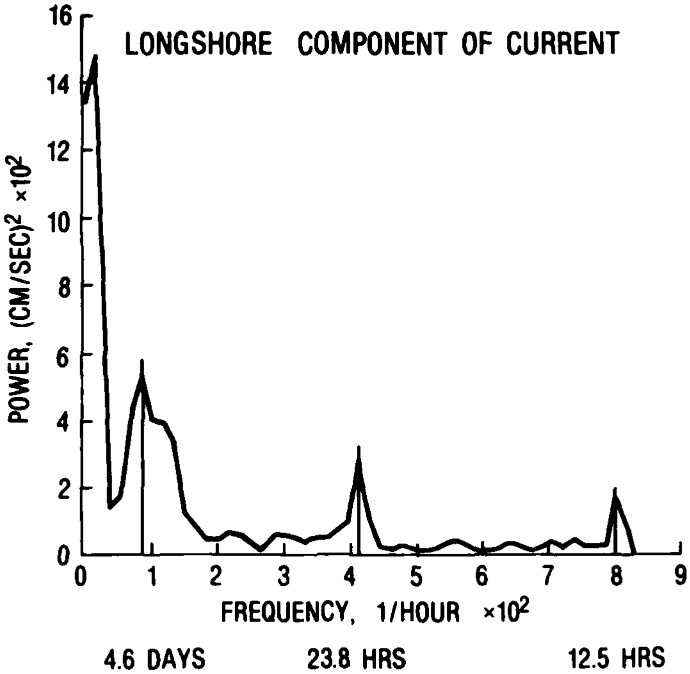

FIGURE 7. POWER SPECTRUM OF THE LONGSHORE CURRENT FOR THE PERIOD MAY THROUGH AUGUST 1984 FROM THE CURRENT METER SOUTH OF THE FRF PIER END

weekly cycle may be due to the passage of larger scale weather systems.

Evidence that these peaks in the longshore current spectrum are weather related is provided by the information in Figure 8 which shows the spectrum of the longshore component of wind for the same May through August period. Peaks are present in the wind spectrum at approximately the same periods as in the current spectrum with the exception of the peak at the tidal period. There is also some qualitative evidence in the time series that a longer cycle on the order of 20 days may be present. Longer time series are needed to verify this.

An example of the response of the longshore current to the wind is shown in Figure 9. The longshore component of current and wind are plotted for the period 12-21 May 1984. When the wind shifts to a shore parallel direction 15-18 May, the longshore current tracks the wind speed with a response time of less than 6 hr.

Work has just begun on relating the FRF environmental factors to the nearshore current climate. These preliminary results offer, however, the possibility of predicting the nearshore current climate from weather records at

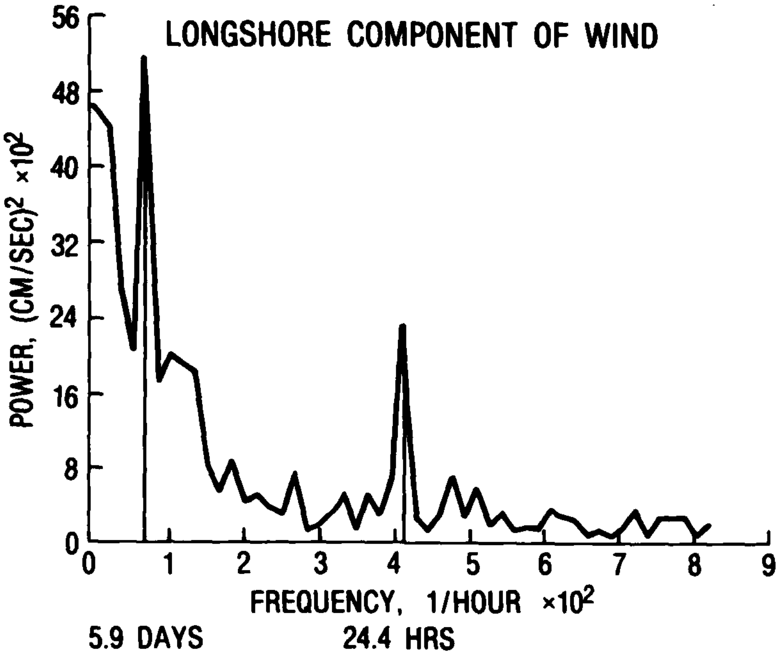

FIGURE 8. POWER SPECTRUM OF THE LONGSHORE WIND FOR THE PERIOD MAY THROUGH AUGUST 1984 FROM MEASUREMENTS ON THE FRF BUILDING

or near a coastal site. Such records are more numerous and of longer duration than direct measurements of nearshore currents. If we assume that the major factors affecting the nearshore current are the wind, local wind-generated waves, swell, and the tide, we can determine three out of four from local weather and tide records. The swell component is independent of local weather and tide, but it could be estimated at a site from the Wave Information Study results. In principle, then, we could hindcast or predict the longshore transport at a site using readily available data.

PLANNED FIELD MEASUREMENTS

Measurements of currents, waves, and winds nearshore are planned for 20 days in September 1985 at the FRF. Proposed measurement locations are shown in Figure 10. These measurements are planned to answer questions raised by analysis of previous data such as, "What is the variability of the current, wave, and wind fields in the longshore, cross-shore directions and in time?" We will be paying closer attention to the wind than in the past. Measurements will be made from the pier end and pier building to determine if land effects

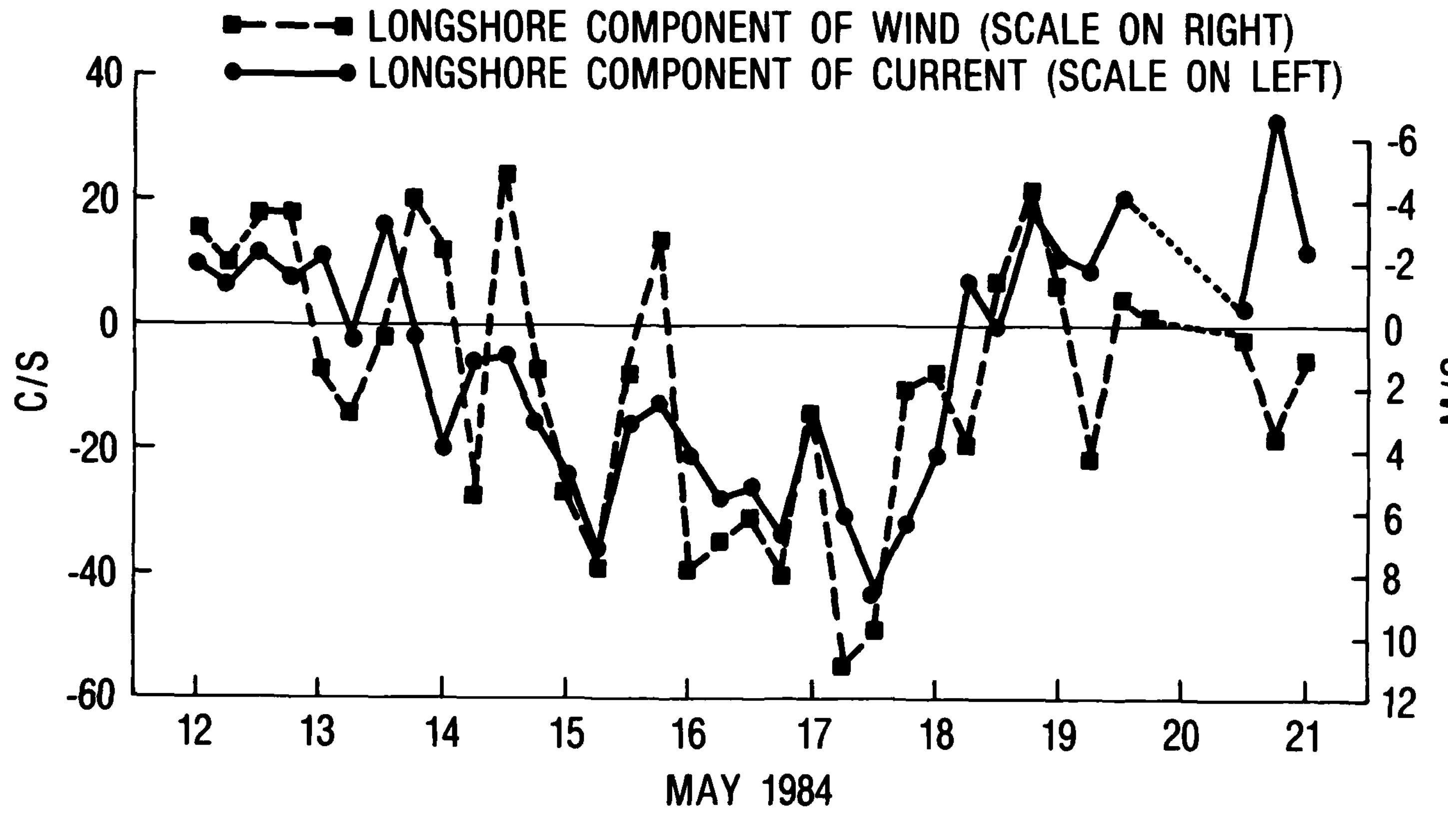

FIGURE 9. TIME SERIES OF LONGSHORE COMPONENT OF WIND AND CURRENT FOR THE PERIOD 12 MAY TO 21 MAY 1984 AT THE FRF

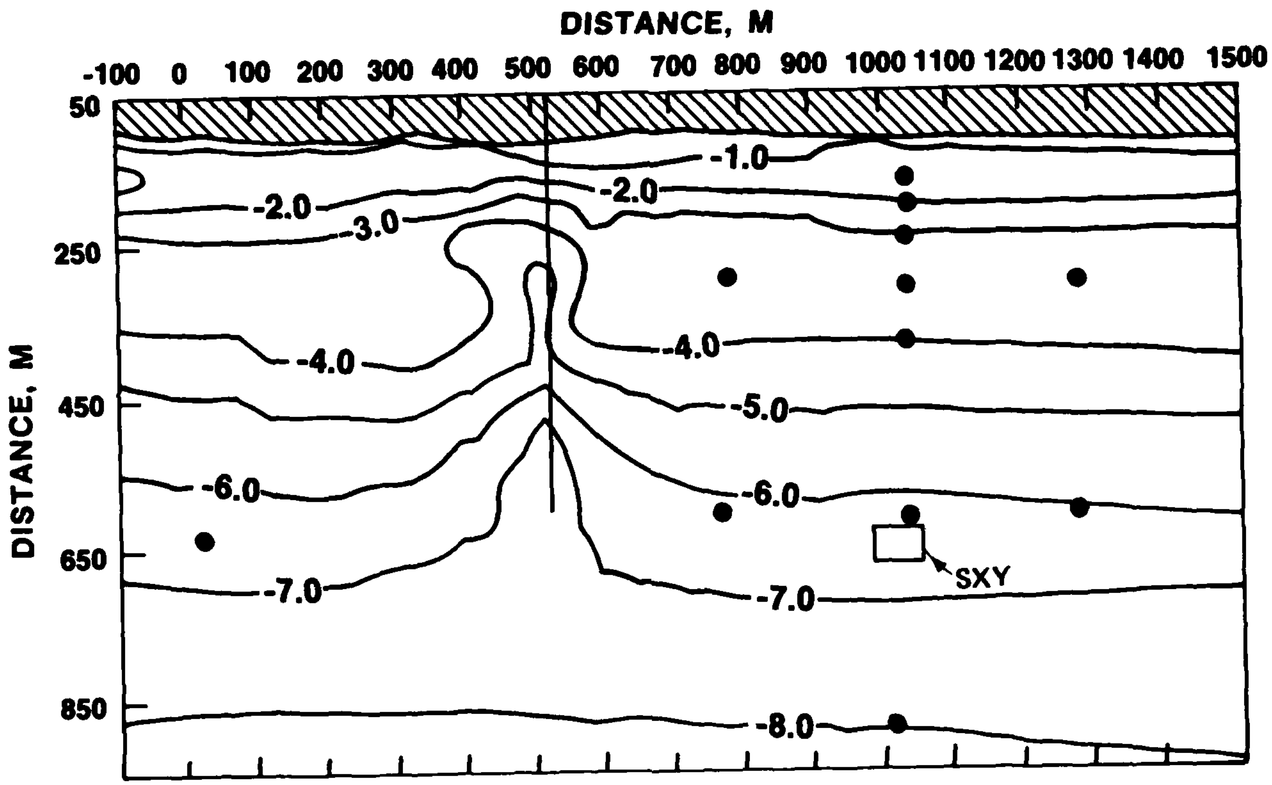

FIGURE 10. LOCATION OF PROPOSED MEASUREMENTS AT THE FRF DURING SEPTEMBER 1985

are present. Temperature of the air and water will be measured to detect changes in air or water masses indicating the passage of fronts. The measurements will be used to calibrate and verify a simplified one-dimensional version of the nearshore current modeling system and the two-dimensional version. In addition, these measurements will support other investigators who are looking at problems dependent on nearshore waves and currents.

ACKNOWLEDGEMENTS

The research presented in this paper was conducted as part of the "Nearshore Waves and Currents Work Unit," Harbor Entrances and Coastal Channels Program, Coastal Engineering Functional Area, Civil Works Research and Development, US Army Corps of Engineers.

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DISCUSSION

PROF. WIEGEL: It's not a question; it's a comment. I've been looking at a lot of data on the currents, both fixed measurements of currents and those supplemented by a very extensive series of drogue measurements used by Scripps. They've developed a new type of drogue that you can get in and out very easily. And now our water depths are deeper. Just a little offshore we have 20- or 30-m depths 1,000 m offshore. The bottom bathymetry affects the measurements very strongly; there will be some very rapid shifts. I think you're starting to see some of these kinds of things. And there are a number of things; we just simply have no clue yet as to what might cause them. Now I don't know about the East Coast, but on the West Coast we have the general circulation which would be the so-called California current. We say so-called because the more they study it the less they know about it. When they had a few data they understood it. And then we developed countercurrents. Upwelling systems in all of these things affect this and, as I said, I am beginning to see in some of these things some of the same complexities.

But how much of these phenomena were due to the sample length in the way it's analyzed? Is that a real peak at very low frequency?

DR. HUBERTZ: I subtracted the mean from the series which is supposed to help get rid of those high peaks at the very low frequencies, and I've looked at time series plots similar to the scatter diagrams that I showed. You can see when you look at an expanded scale an oscillation on the order of 20 days. But my time series wasn't long enough in the current time series to show that up statistically in the spectrum. Now in the wind time series where the anemometer is operating continuously that will show up better. Hopefully we'll be able to get that current meter to run through length of time in which we can pick that up. But I wouldn't be surprised at all that we don't have something on the order of a 20-day cycle, also.

PROF. WIEGEL: Thank you.

DR. NUMMEDAL: *Whenever I've flown over that part of the North Carolina coast, there are rip currents all over the place. Are there rip currents in the study area? If so, what have you done up and down along the coast in your current data?*

DR. HUBERTZ: Well, in the situation that I showed first where we had the measurements along the profile line, we didn't, on those two occasions, see any rip currents at that location. Down at the FRF, the rip currents seem to prefer that trough underneath the pier, which is a natural mechanism for them to shoot out. By making the measurements that I've indicated here where we've got some distribution on longshore direction, I'm hoping that if we get a case where we have a rip current, I might be able to pick up part of it, if we're lucky. We didn't see any when we made the measurements, either on the profile line or over at that one particular point. But they are present down there.

BARRIER ISLAND SEDIMENTATION STUDIES

CERB
Proceedings

Dr. Suzette Kimball May
Research Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Mr. Stephen C. Knowles
Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The Barrier Island Sedimentation Study is designed to develop the capability to predict barrier island geomorphic adjustments to both long- and short-term processes. Seventeen projects at eight field sites are being utilized to develop comprehensive data sets. The data will help verify models of depositional environments, sediment budgets, and barrier island response to coastal processes. A recently completed study documents the importance of inlets to the dynamics of barrier island retrogradation in Virginia and southern New Jersey. Core data and historical maps and charts show the progressive infilling of the backbarrier systems. This study documents the importance of sediment transport through the inlets and subsequent redistribution within the lagoon to provide barrier island substrate. A study is being made also of the Ocean City Inlet area to assess the processes responsible for rapid recession of the northern end of Assateague Island, Maryland. The observed changes at Ocean City represent adjustments to long-term coastal processes, such as sea level rise, possibly accelerated by the effects of inlet stabilization. Presented in this paper is a discussion of each of these studies.

INTRODUCTION

More than 295 barrier islands comprise over half of the United States' oceanic shorelines between Maine and Florida and west to Mexico. Barrier islands are important buffer zones that protect the mainland from flooding and other damage associated with storm surge and high waves. They are geologically young features, and their forms differ significantly in response to varied wave, current, tidal, and storm conditions.

There is no generally accepted theory of barrier island formation. Common elements of most proposed theories include large volumes of available sediment, low gradients, and a gradual rise in sea level since the Wisconsin glacial period. Increased rates of shoreline recession will result when sediment supply is decreased or when the rate of sea level rise increases.

Barrier coastlines are important both economically and recreationally. Because of their unique qualities and their dynamic natures, there exists a need for better understanding of barrier island origins, long-term development, and short-term variability in order to establish successful methods for the utilization and protection of these systems. It is essential to develop the capability to predict the systems' evolutionary trends to meet policy and planning objectives.

BARRIER ISLAND SEDIMENTATION STUDY

The Barrier Island Sedimentation Study is a major research unit designed to obtain and analyze data to support model development and calibration for the purpose of predicting island response to a variety of forcing processes. The objectives of this effort are to:

(1) Evaluate theories of evolution of barrier island systems.

(2) Develop models to predict their geomorphic development.

(3) Assess sediment budgets, including sources and sinks of material, sediment characterization, and depositional environments.

(4) Model shore-zone morphologic responses on short-term (seasonal), meso-scale (10-150 year), and long-term (geologic time frame) scales.

(5) Project sediment availability in a variety of time frames.

Data collected and analyzed include time histories of barrier island formation, washover characteristics, subsidence rates, the effects and rates of inlet processes and sea level variations, and nearshore sediment dynamics. Integrated field and laboratory investigations are designed to address these issues.

Currently, field studies are being carried out at eight locations along the Atlantic and Gulf coasts. Typical field data collections include vibracores, surface samples (grab and box cores), elevation monitoring, and subbottom profiling (seismic and acoustic). Laboratory analysis of cored sediments includes rapid sediment analyzer (RSA) and sonic sifter processing, mineralogic and micro-paleontologic profiles, stratigraphic assessments, x-radiography, and radiocarbon (^{14}C) dating. The organic components of back-barrier sediments are also analyzed. Support information is acquired from evaluations of historical maps and charts, aerial imagery, historical data sets, and oceanographic data collections (waves, currents, storms). Results are integrated into scenarios of geomorphic development and predictions of future conditions.

Two recent studies are illustrative of the approach and applications of these research efforts. A comparison of the barrier stratigraphy of southern New Jersey and the Virginia Barrier Islands is the culmination of 2 years of intensive field work. A model of geomorphic development has been designed, including detailed descriptions of depositional environments. These data have been used to corroborate rates of sea level rise and project future conditions.

Ocean City Inlet, Maryland, opened in 1933 and was stabilized in 1934. Rapid recession of the shoreline south of the inlet has been blamed on the jetty system. Ongoing research indicates that high rates of recession were occurring in the area prior to inlet formation, and large-scale, long-term process conditions are significant agents of radical changes in the area.

GEOMORPHIC RESPONSE OF INLET-DOMINATED ISLAND SYSTEMS

Landward movement or narrowing in place of barrier islands is occurring along many shorelines in response to a rise in relative sea level elevation and/or a deficit of available coastal sediment. The rates of barrier island movement and the development of the backbarrier region may be better understood by studying the surface and subsurface sediments of the barrier island and backbarrier environments. These sediments reflect the relative importance of inlets, overwash processes, and fluvial runoff as means for backbarrier accumulation and substrate formation.

Information obtained from cores is combined with geomorphological evidence of historical changes within the barrier island systems. The geological and recent history and probable future appearance of the study area are thus determined. The rise of sea level and change in its rate have had an apparent influence on barrier island translation which, in turn, has affected sedimentation in the backbarrier region. Other factors contributing to the depositional history include the pre-Holocene topography, local tectonism, glacio- and hydro-isostasy, and sediment availability.

Many modern barriers, like the New Jersey and Virginia islands, exhibit a transgressive nature due to a rising sea level and limited sediment supply (McIntire and Morgan, 1963; Hoyt, 1967; Dillon, 1970; Pierce and Colquhoun, 1970; Hoyt and Henry, 1971; Swift, 1975; Belknap and Kraft, 1977; Moslow and Heron, 1979). Morton and Donaldson (1973) and Halsey (1978) determined that the present configuration of the Virgnia segmented barriers has been maintained through the Holocene transgression. Vertical crustal movement (Holdahl and Morrison, 1974) and glacial isostatic adjustments (Clark, 1981) may account for locally slower Holocene relative sea level rise along the Virginia barrier islands when compared to those in New Jersey.

This study examines the surface and shallow subsurface sediments of the barrier islands and adjacent backbarrier regions of southeastern New Jersey and Virginia (Figures 1A and 1B). A conceptual depositional model is created that reflects the Holocene sea level history on the barrier island systems and incorporates past and predicted sedimentation patterns. The depositional model is developed by characterizing the physical and biological characteristics of each subenvironment within the study area. These include barrier islands, tidal inlets, salt marshes, subtidal lagoons, and tidal channels (Figure 2). The effects of a relative sea level rise and/or local net sediment deficit are examined.

Study Area

The area of investigation includes two barrier island systems. One extends 75 km in New Jersey, from Brigantine Island to Cape May. The other extends from Assawoman Island to Smith Island, Virginia (70 km). Cross-shore limits of the study areas are the lower foreshore of the barrier islands to the mainland shoreline of the lagoon. The islands are approximately 5 to 20 km long and 0.3 to 3 km wide.

The Atlantic coasts of New Jersey and Virginia have a semidiurnal tide with a range of about 1 to 1.3 m. The predominant wind direction is from the northwest to northeast and is most prevalent during autumn and winter, with winds of magnitude often greater than 32 km/hr (US Army Engineer District, Norfolk, 1971). The northerly winds produce currents and a wave approach direction from the north which result in a generally net southerly longshore transport of sediment. The backbarriers of both regions, whether open water or marsh filled, are limited by sharp linear contacts with the upland. The adjacent upland is composed of Pleistocene fluvial and marine sands and gravels and is 2 to 3 m higher in elevation than the marsh surface.

Methods

The data base for this study consists principally of deep vibratory

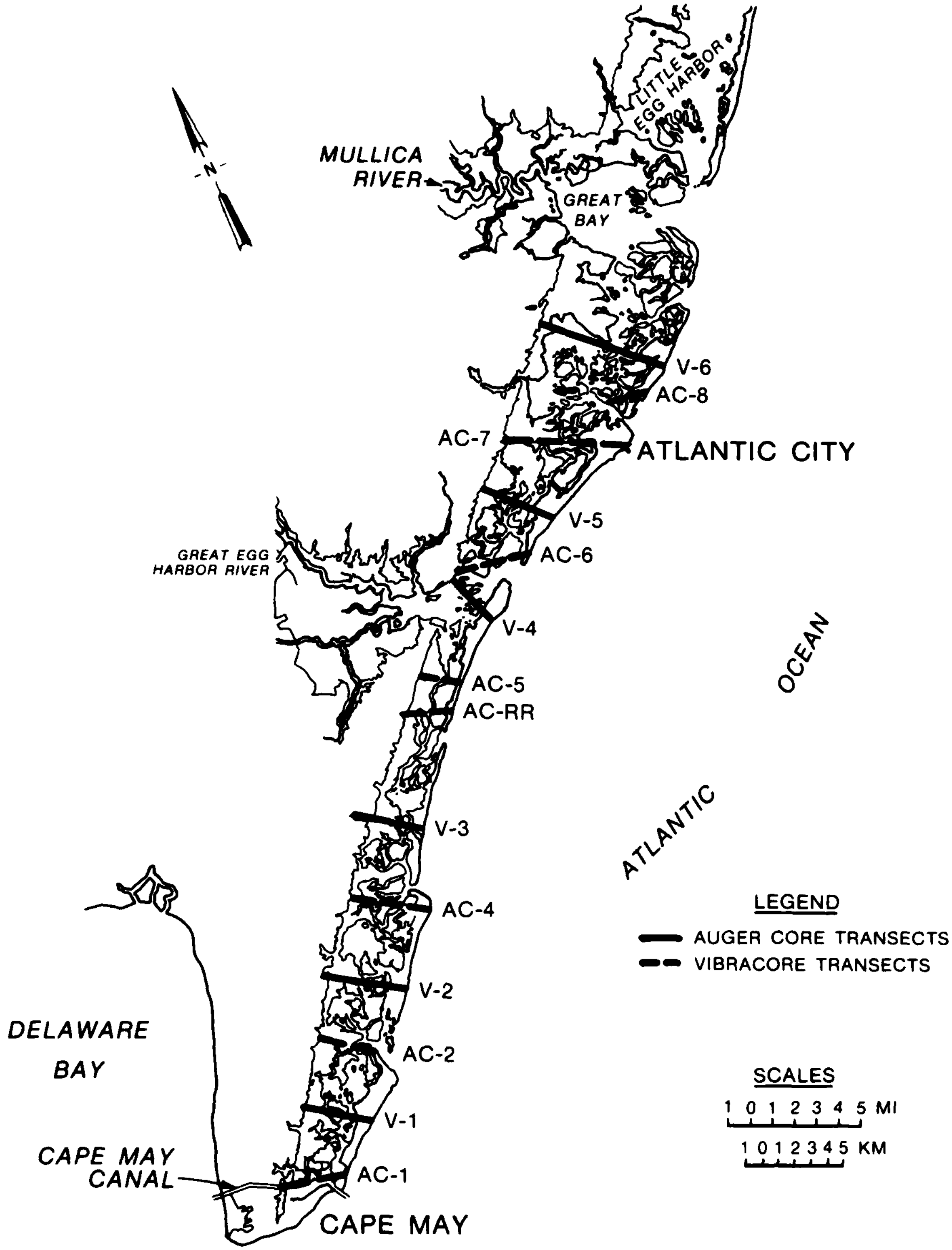

FIGURE 1-A. REGIONAL SETTING OF THE STUDY AREA: NEW JERSEY

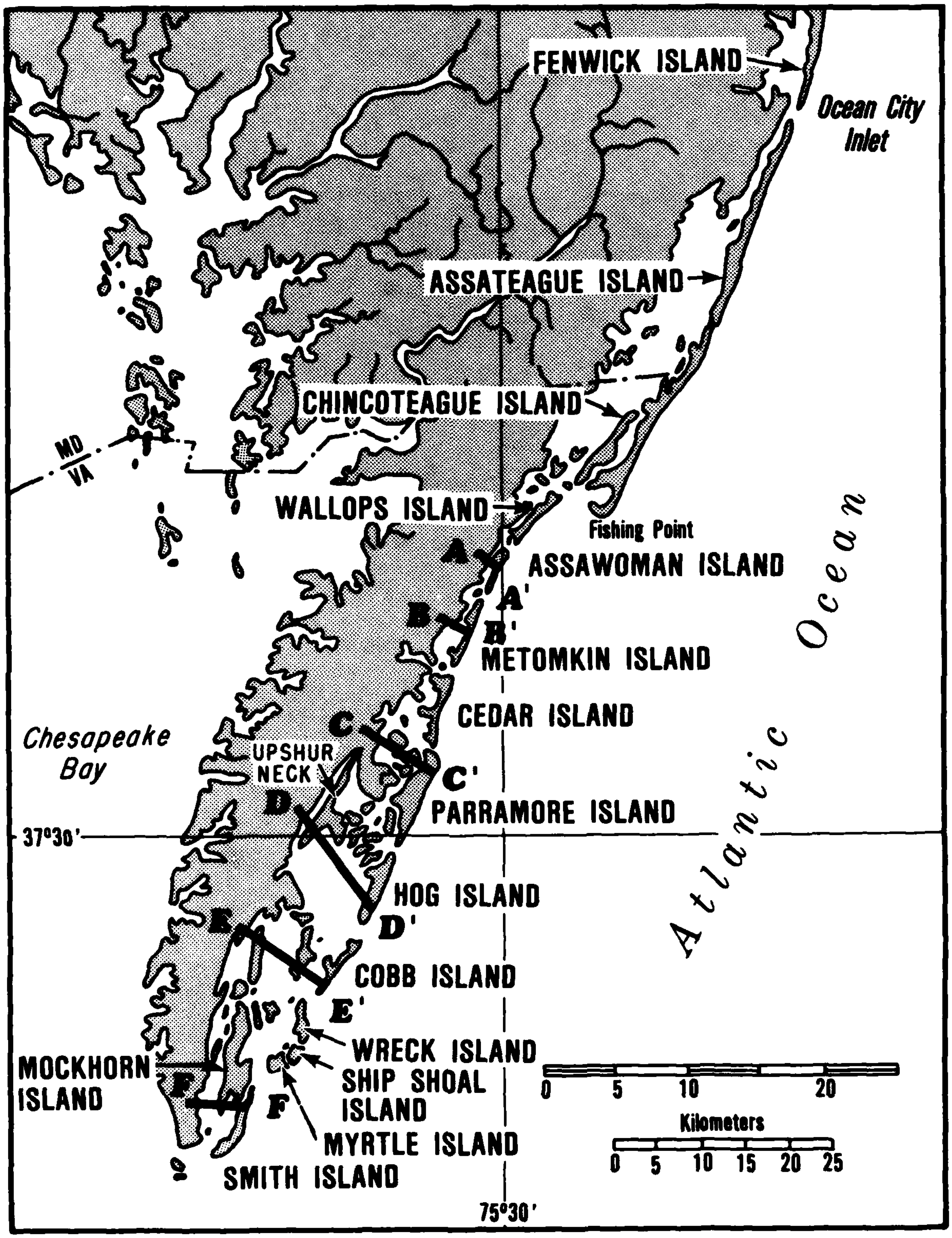

FIGURE 1-B. REGIONAL SETTING OF THE STUDY AREA: VIRGINIA BARRIER ISLANDS AND OCEAN CITY/ASSATEAGUE ISLAND

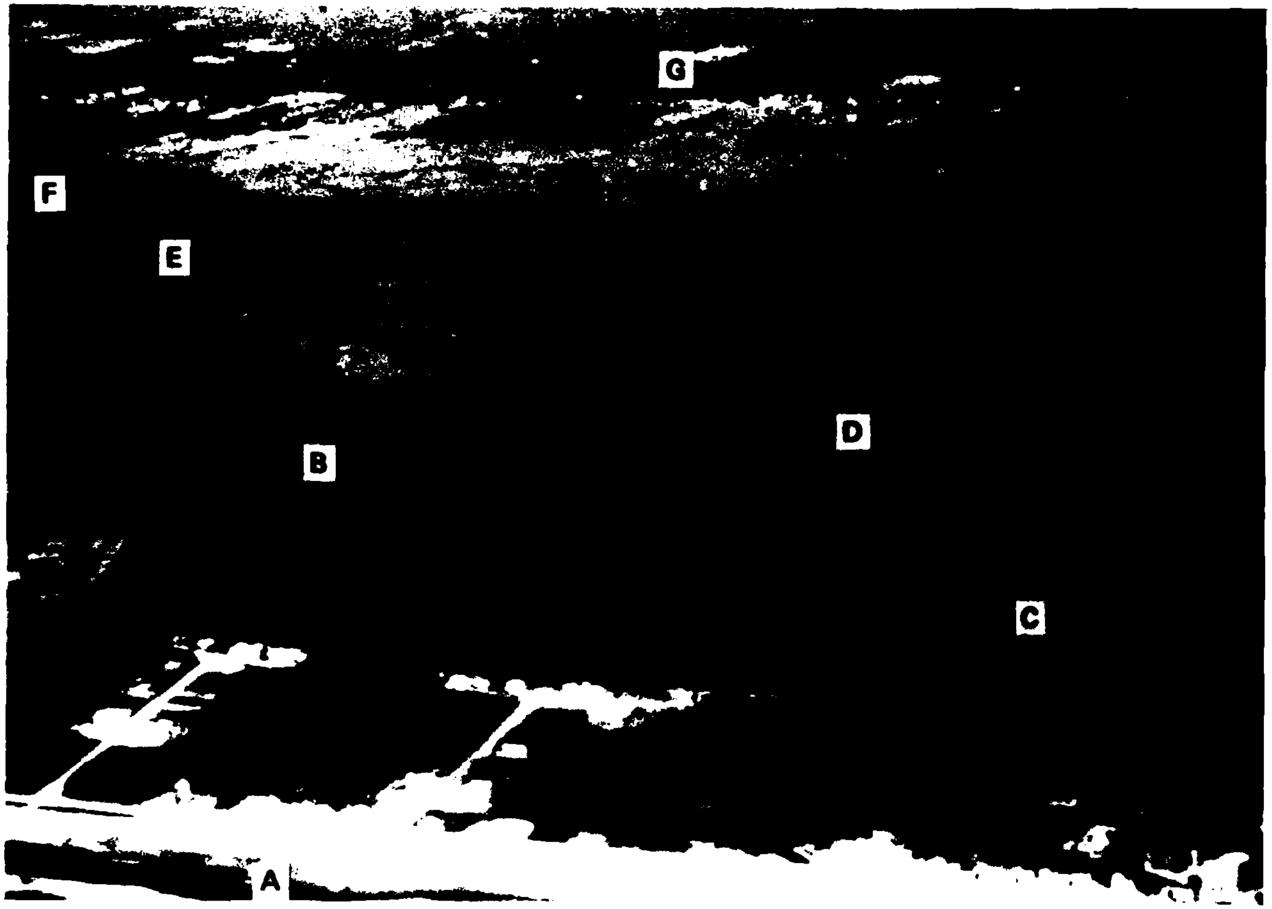

FIGURE 2. AERIAL VIEW REPRESENTING VARIOUS SUBENVIRONMENTS OF THE BARRIER SYSTEM: (A) BARRIER ISLAND, (B) TIDAL MARSH, (C) TIDAL CHANNEL, (D) TIDAL CREEK, (E) MUDDY TIDAL FLAT, (F) ENCLOSED OPEN BAY/SHELTERED LAGOON, (G) MAINLAND

cores from the barrier islands and backbarrier regions. The core data were supplemented by information obtained from historical maps and charts, recent aerial photographs, and topographic maps. The vibracorer and extraction tripod used is described by Finkelstein and Prins (1981). A total of 66 vibracores and augercores, 4 to 10 m long, was collected along 15 shore normal transects in New Jersey (Figure 1A). Thirty-four vibracores were taken on the six Virginia Barrier Islands (Figure 1B).

All cores were split, photographed, and described in detail in the laboratory. Description of each core included the major sedimentary structures (physical and biological) and any plant and animal remains (microfauna and macrofauna). Sediment samples were selected toward the middle of each lithosome. Textural and mineralogical analyses were completed using standard techniques (Folk, 1974). Heavy minerals in selected barrier and backbarrier sand samples were separated in bromoform (specific gravity 2.90) and identified. Representative cores containing backbarrier sediments were selected for x-radiographs using methods by Bouma (1969) and Howard and Frey (1975). Eight New Jersey and twenty-four Virginia ^{14}C age dates were obtained where suitable organic material was present (Table 1).

RESULTS

Sedimentology

Surface and subsurface sediments range in age from pre-Holocene to Modern and represent the entire sequence of estuarine depositional environments. The sediment consists almost entirely of terrigenous sand, silt, and clay. Shells and shell fragments of mollusks and foraminifera and authigenic grains of glauconite comprise most of the nonterrigenous component of the sediment. The descriptions of the core and surface samples provide sufficient data for the recognition of seven Holocene lithosomes--beach, modern marsh, oyster-dominated muddy tidal flat, mixed flat, sand flat, sheltered lagoon, and basal Holocene--and one comprehensive pre-Holocene lithosome. The principal lithosomes are shown in Figure 3 as a schematic drawing.

Microfossils add valuable information concerning the environment of deposition and the source of the sediment. Foraminifera and ostracodes were separated from backbarrier cores. The assemblages of foraminifera suggest that most of the backbarrier sediments penetrated by the cores were deposited

TABLE 1
RADIOCARBON-14 AGE DATES

Core Number and Depth (m)		Transect	Lab Number	Type of Material	Date B.P.
				New Jersey	
1-3-9,	4.50	1	B-6081	Oyster shell	2,100 ± 80
3-3-8,	2.65	3	B-6084	Organic rich mud	730 ± 90
3-3-11,	5.00	3	B-6083	Spartina alterniflora	2,880 ± 70
3-4-7,	2.10	3	B-6086	Spartina alterniflora	1,750 ± 60
5-2-3,	2.80	5	B-6090	Organic rich mud	2,460 ± 80
5-4-13,	6.55	5	B-6088	Sandy peat	2,760 ± 150
5-5-7,	3.60	5	B-6087	Organic rich mud	2,210 ± 80
6-3-6,	2.05	6	B-6085	Spartina alterniflora	2,050 ± 160
				Virginia	
1-1,	0.91	A-A'	B-2659	Spartina alterniflora	650 ± 60
1-4,	0.60	A-A'	B-2660	Spartina alterniflora	700 ± 60
1-4,	4.73	A-A'	B-2661	Organic rich muds	2,440 ± 70
1-4,*	5.20	A-A'	W-4789	Organic rich muds	3,200 ± 100
1-4,	5.41	A-A'	B-2662	Basal peat	3,580 ± 60
2-1,	1.05	B-B'	B-2663	Spartina alterniflora	1,180 ± 60
2-2,	6.60	B-B'	B-1952	Basal peat	4,620 ± 80
2-3,	1.68	B-B'	B-1951	Spartina alterniflora	1,660 ± 70
2-4,*	2.45	B-B'	W-4788	Basal peat	2,200 ± 80
3-2,*	2.13	C-C'	W-4792	Oyster shell	600 ± 60
3-2,	3.80	C-C'	B-1954	Marsh debris in mud	3,640 ± 110
3-5,	1.22	C-C'	B-1955	Oyster shell	1,380 ± 90
3-5,*	4.72	C-C'	W-4787	Oyster shell	2,900 ± 110
4-4,	0.30	D-D'	B-1959	Spartina alterniflora	Modern
4-5,	0.86	D-D'	B-2664	Oyster shell	450 ± 50
4-6,	0.96	D-D'	B-2665	Oyster shell	890 ± 70
5-1,	3.35	E-E'	B-1956	Marsh debris in mud	3,160 ± 70
5-2,	1.55	E-E'	B-1957	Oyster shell	890 ± 60
5-4,	0.30	E-E'	B-2667	Spartina alterniflora	Modern
6-5,	3.90	F-F'	B-1949	Sandy peat	23,350 ± 370
6-5,	3.90	F-F'	B-3423	Sandy peat	30,870 ± 470
6-6,	0.41	F-F'	B-1948	Spartina patens	1,430 ± 80
6-6,	0.80	F-F'	B-1950	Willow or tulip poplar	1,7[illegible] 100

* Radiocarbon dates from USGS, Reston; all others from Beta Analytic, Inc., Coral Gables, Florida.

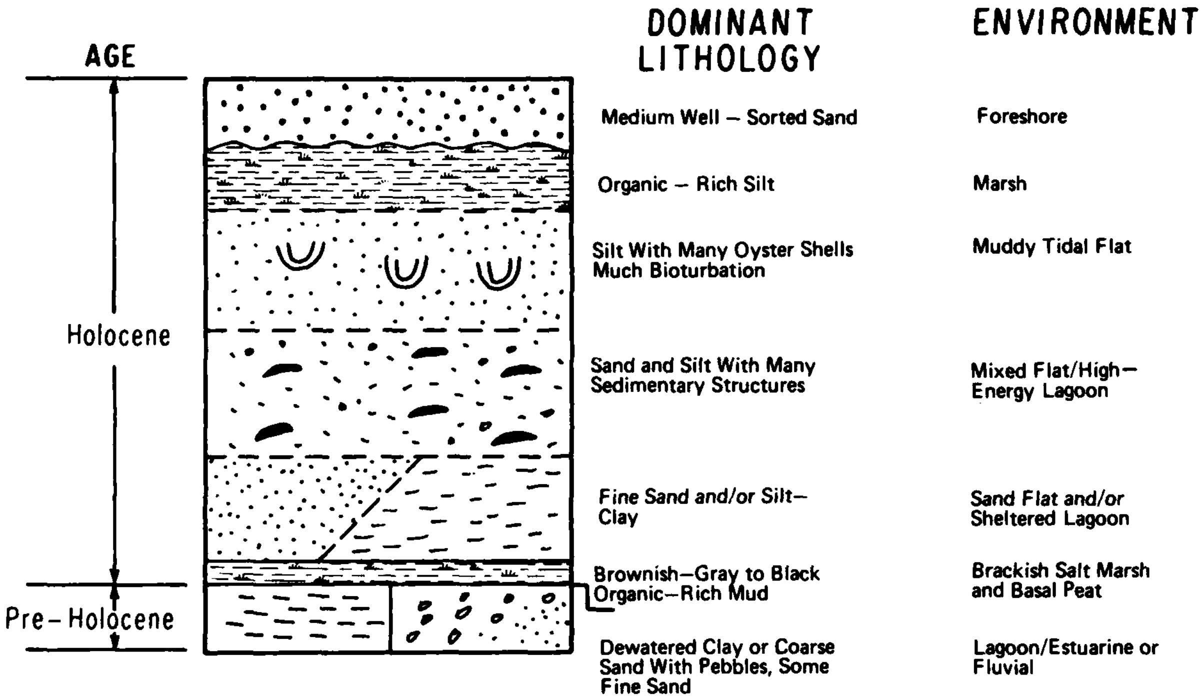

FIGURE 3. SCHEMATIC DRAWING OF GENERALIZED CORE INDICATING PRIMARY LITHOSOMES (Note: trend of higher to lower energy environments from bottom to top)

under relatively uniform environmental conditions. The relatively few agglutinated foraminifera below the immediate surficial layers suggest that marshes were less widely developed during accumulation of the backbarrier sediments than they are at present. The ostracodes found are consistent with the environments of deposition as proposed by the lithosome identification. Shallow marine species taken from a mixed flat are further evidence that sediments of this lithosome were deposited in a more open, unrestricted, subtidal marine environment.

Sea Level Data

Dating of organic material in vibracore samples was determined by ^{14}C methods. The organic materials are useful for determining a relative sea level curve because they are indicators of past sea levels. Basal peats are the most useful because the initial inundation of the sea is recognized, and subsequent compaction of pre-Holocene sediments during Holocene time has been negligible in this area. The tidal range must be added or subtracted to past sea levels when locating and dating intertidal organic materials such as oysters or marsh vegetation. The tidal range of this study area is assumed constant throughout the Holocene.

Figure 4 shows a relative sea level curve developed from ^{14}C dates of oysters, intertidal marsh vegetation, basal peats, and brackish salt marsh sediments. The results are consistent with those of Stuiver and Daddario (1963), i.e., an average rate of sea level rise of 2 mm/year in New Jersey, with sea level rising relatively rapidly between 6,000 and 2,200 years B.P. and much more slowly since then. From approximately 2,000 to 500 years B.P., sea level is shown to have risen very little. A deceleration in the rate of sea level rise is indicated by samples less than 1,000 years B.P.

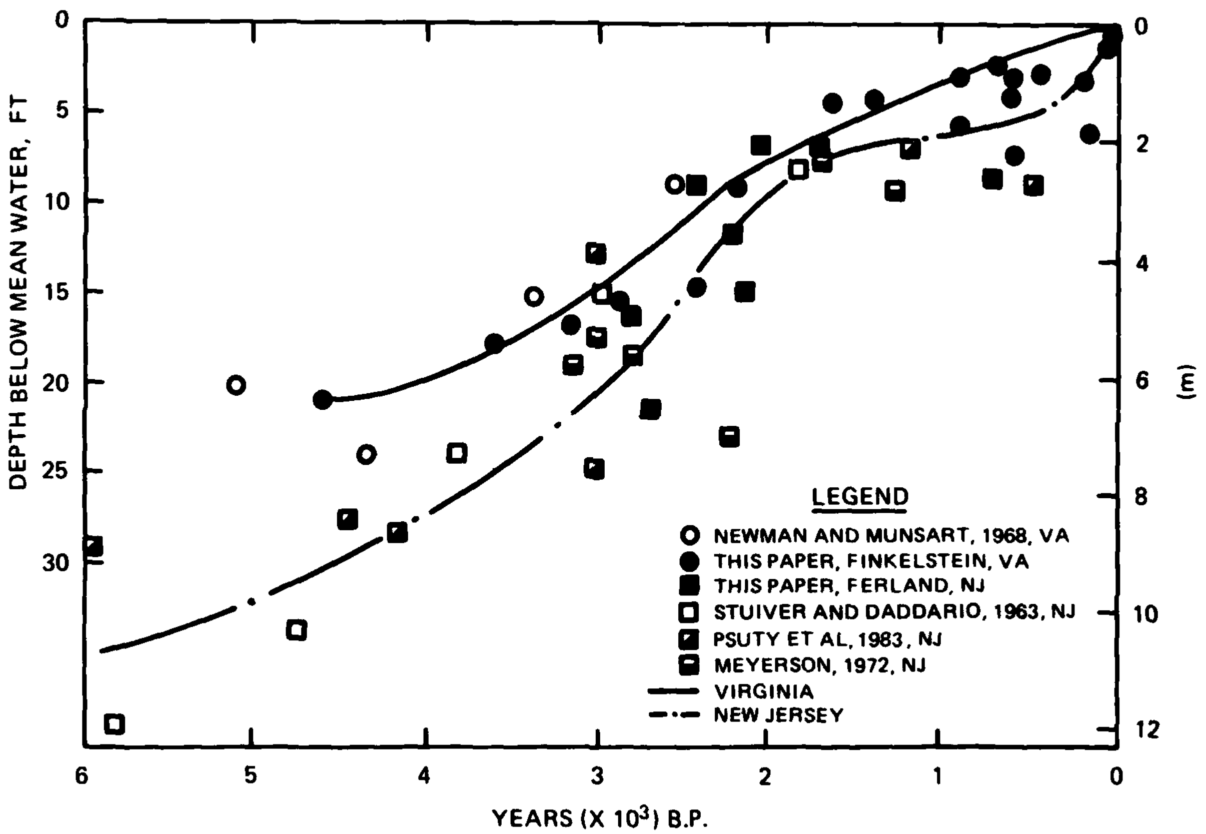

FIGURE 4. A SEA LEVEL CURVE FOR THE STUDY AREA FROM APPROXIMATELY 5,000 YEARS B.P. (VIRGINIA) AND 6,000 YEARS B.P. (NEW JERSEY) TO THE PRESENT

The Virginia sea level curve from this study and the basal peat dates of Newman and Munsart (1968) are also shown in Figure 3. Two inflection points can be seen on the Virginia sea level curve. One indicates the commencement of a period of relatively rapid sea level rise at about 3,800 years B.P. and the other a period of relatively slow rate of rise beginning about 2,200 years B.P. The overall Virginia rate of sea level rise is 1.3 mm/year calculated from dates since 4,600 years B.P. Rates of sea level rise are shown to be higher in New Jersey than in Virginia. Comparisons to other regional or often cited sea level curves are shown in Figure 5.

Barrier Sediment Sources

Three potential sources of sediment to the backbarrier are overwashed nearshore and barrier island sediments, drainage from the upland, and inlet transported marine sediments. The relative proportion of each indicates the processes which are dominant in filling the backbarrier.

Overwash occurs in many locations in the study area, specifically on spits adjacent to tidal inlets and along the many low-lying beaches. Shore protection structures, present along much of the New Jersey shore, prevent most washover fans from occurring except during the most extreme storm events. The large total width of the backbarrier system precludes significant contributions of overwash to the sediment budget.

The Pleistocene upland is believed to have been a major source of sediment during the early filling of the backbarrier. Stratigraphic evidence

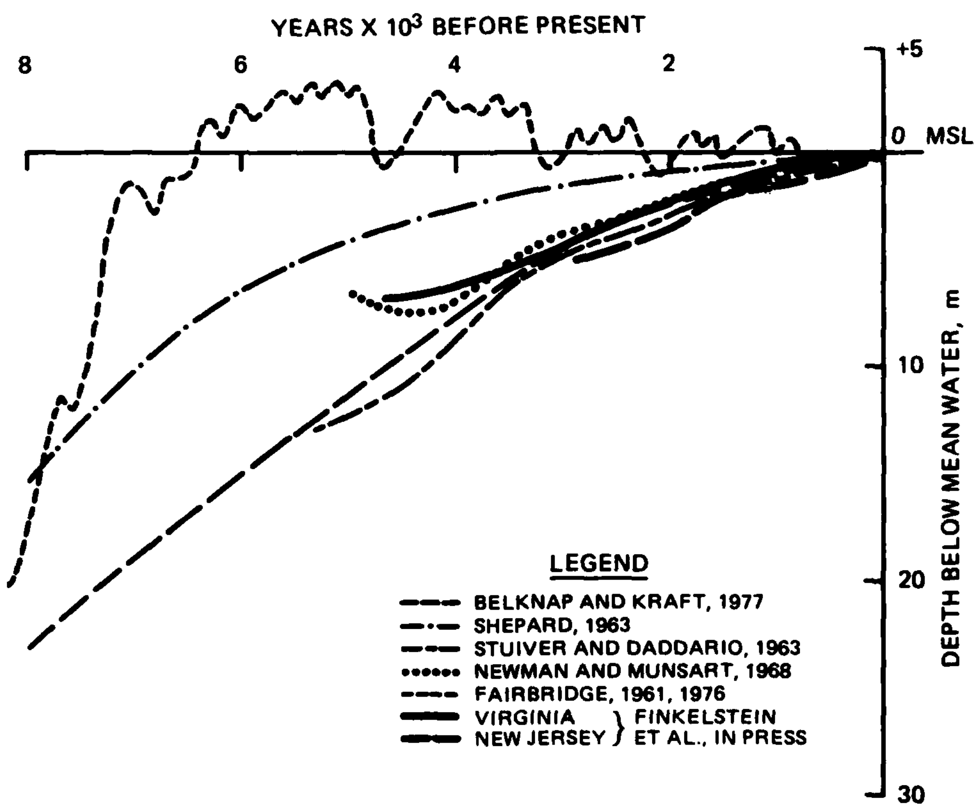

FIGURE 5. OTHER REGIONAL AND OFTEN CITED SEA LEVEL CURVES FOR COMPARISON TO CURVES DERIVED THROUGH THIS STUDY

supports this hypothesis. During the early Holocene, barrier islands were most likely much seaward of their present positions. Short period waves, characteristic of inland waters, can erode a well-vegetated shoreline, thereby liberating sediment for subsequent transport into the adjacent lagoon. Presently, however, the few rivers and creeks which enter the backbarrier are largely impounded and carry relatively little suspended sediment (United States Geological Survey (USGS), 1974-1978).

Backbarrier subsurface data indicate that inlets represent the greatest avenue of transport of littoral and inner shelf sediments into the backbarrier. Marine derived sediments enter the backbarrier on flood tides, possibly deposited on flood tidal deltas, and are subsequently redistributed by tidal currents. Sands are deposited proximal to the inlets as the velocities drop in the tidal channel network. Silts and clays are carried to more distal portions of the marsh complex. The stratigraphic record points to a Holocene infilling process as subtidal sand, and mixed flats are vertically replaced by intertidal mudflats and marsh. Onshore transport of sediment within the study area has been shown also by Meza and Paola (1977) and Kelley (1980, 1983).

<u>Summary</u>

New Jersey and Virginia mid- to late-Holocene rates of relative sea level rise are generally equivalent to those determined in other mid-Atlantic regions. New Jersey and Virginia have sea level rise rates of approximately 2 and 1.5 mm/yr, respectively, over the past 5,000 years. Sea level rise has slowed since 2,200 years B.P. Fluctuations in the sea level curves are supported by core data and regional literature.

The sedimentology, stratigraphy, and microfauna imply a transition from a higher to a lower energy backbarrier environment throughout Holocene time to the present. This reflects the retreat of the barrier islands and narrowing of the lagoons. Continuous retreat of the barriers has caused a decrease in the tidal prism and probable constriction of the tidal inlets resulting in further backbarrier restriction.

Sediment is mainly introduced into the backbarrier environment through tidal inlets. Backbarrier core data show no evidence that washover or mainland sediments constitute a significant backbarrier sediment source. Core data and historical maps and charts indicate a trend of tidal flat and marsh infilling of the backbarrier environment.

The retreat of the barrier islands is caused by sea level rise and lack of available sand size sediment. Presented is a scenario of (1) rapid sea level rise and barrier island retreat with high energy backbarrier sedimentation prior to 5,000 years B.P., (2) slower sea level rise and barrier retreat with continuous narrowing of the lagoons and subaqueous backbarrier sedimentation between approximately 5,000 to 2,200 years B.P., (3) a much slower sea level rise after 2,200 years B.P., with a change from subaqueous to intertidal sedimentation in many areas, and (4) rapid historical sea level rise which causes rapid barrier island retreat in sand starved areas.

GEOMORPHIC CHANGE AT OCEAN CITY INLET, MARYLAND

Ocean City Inlet is located along the microtidal Atlantic Ocean coastline of Maryland (Figure 1B). The inlet separates Assateague Island to the south from Fenwick Island to the north. Ocean City Inlet was opened by a hurricane in 1933 and stabilized with a double jetty system in 1934. Since 1933, dramatic shoreline recession has occurred downdrift of the inlet, with accretion to the north. Analysis of these trends has led past researchers to conclude that inlet stabilization is the principal cause of shoreline retreat. However, study of long-term shoreline position changes, from 1849-1980, reveals that significant shoreline recession (nearly 4m/yr) was occurring in this area prior to inlet formation. Measurement of cartographic areas of northern Assateague Island reveals that barrier migration is the principal cause of the ocean shoreline recession. This study suggests that although inlet formation and stabilization may have accelerated the recession rates, the coastal geomorphic changes observed at Ocean City represent response to long-term coastal processes.

Method of Study

Historical National Ocean Service (NOS) and Coast and Geodetic Survey shoreline surveys and shorelines mapped from 1980 aerial photography were transferred onto 1:24,000-scale USGS quadrangle maps by NOS and National Oceanographic and Atmospheric Administration (NOAA) personnel. These maps were prepared as part of a continuing series of NOS/Coastal Engineering Research Center (CERC) cooperative shoreline position change studies. Descriptions of the mapping techniques and accuracy are contained in Everts, Battley, and Gibson (1983).

The present study analyzes shoreline position changes from 38°28' to

38°10' north latitude, about 16 km north and 18 km south of Ocean City Inlet. The northern and southern boundaries extend a few kilometers out from the ends of a large recessional embayment which existed prior to 1933.

A set of baseline segments was located roughly parallel to the ocean shoreline trends and divided into 50-m increments. The shoreline positions for each date were digitized in relation to the baseline segments with a NUMONICS Model 1224 digitizer. A computer program (FORTRAN) was written to analyze the shoreline position data. Means and standard deviations of annual shoreline position change were calculated for each 50-m transect.

In addition to the shoreline position change analysis, changes in island areas were calculated with the digitizer. Northern Assateague Island was divided into 1-min latitude segments. The areas were measured for each date that included both ocean and bay shorelines.

Results

Figure 6 shows the mean and standard deviation of annual shoreline position change within the study area (~1850-1980). This figure illustrates why previous researchers believed that the inlet is solely responsible for the excessive recession of northern Assateague Island. Accretion increases toward the inlet on the north side with an abrupt change to recession south of the inlet. Analysis of pre- and post-inlet coastal changes in this area reveals a more complete picture.

Prior to 1933, a 16-km-long recessional embayment was centered about 2 km south of the present inlet (Figure 7). Maximum mean annual recession rates approached 4 m/year near the center of the embayment. During the period from 1933-1980, recession-accretion trends changed significantly in the area (Figure 7). Accretion rates on the north side of the inlet were nearly 5 m/year for the post-inlet period. The recession rates of northern Assateague Island approached 8 m/year. The areas of maximum recession were approximately identical for both the pre- and post-inlet periods.

The behavior of northern Assateague Island is often described as erosional. Northern Assateague Island is actually migrating landward, with minimal net erosion during the 131 years of shoreline mapping. Analysis of the measured island area changes in Table 2 reveals that there has been a loss of only 0.13 km^2 along the highly mobile northern end of Assateague, from latitude 38°16' north to the inlet. This represents a loss of only 4 percent of the 1849 island area. The next measured island segment to the south, 38°16'

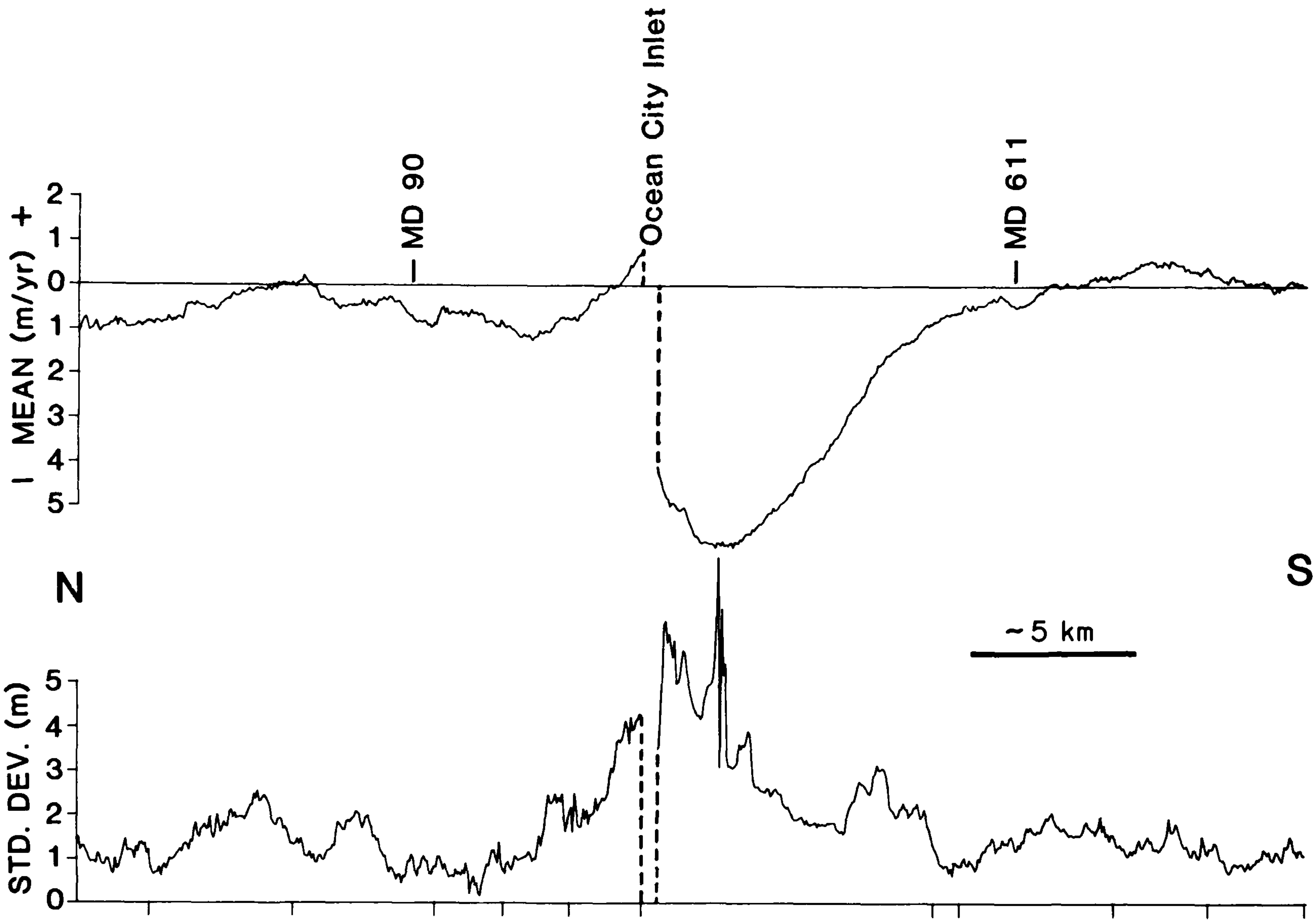

FIGURE 6. SHORELINE POSITION CHANGE, 1850-1980

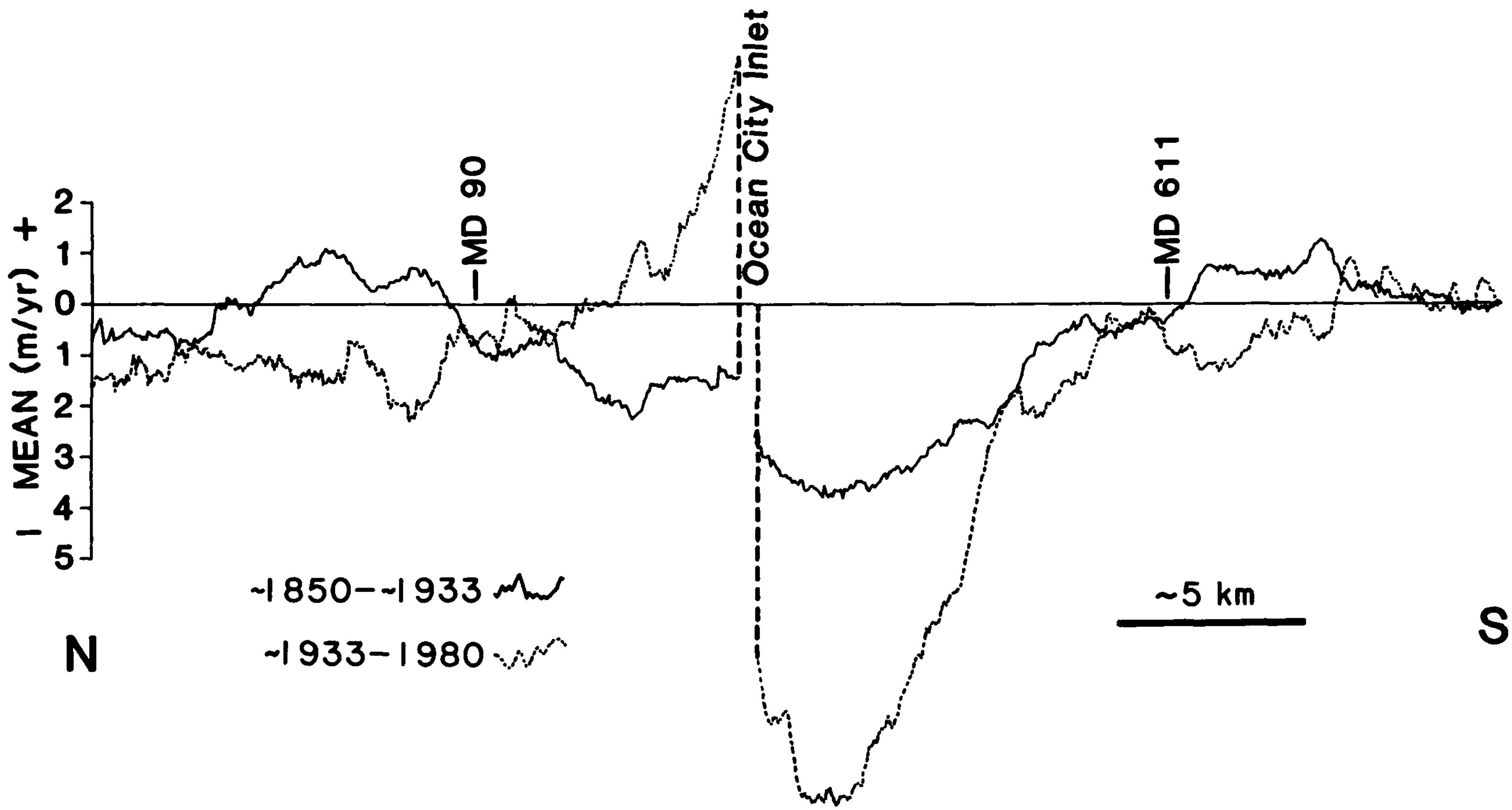

FIGURE 7. PRE- AND POST-INLET SHORELINE POSITION CHANGE

TABLE 2
NORTHERN ASSATEAGUE ISLAND AREA CHANGE, 1849-1980 (km^2)

	1849	1908	Change	1942	Change	1861/1862	Change	1980	Change	Net Change 1849-1980
Ocean City Inlet to 38°19'	0.32	0.25	-0.07	0.30	+0.05	0.31	+0.01	0.40	+0.09	+0.08
38°17'-18'	0.79	0.75	-0.04	0.54	-0.21	0.32	-0.22	0.84	+0.52	+0.05
38°18'-17'	0.94	0.70	-0.24	0.91	+0.21	0.74	-0.17	0.86	+0.12	-0.08
38°17'-16'	0.95	0.81	-0.14	1.12	+0.31	0.82	-0.30	0.77	-0.05	-0.18
38°16'-15'	1.21	1.15	-0.06	1.03*	-0.12	0.93	-0.10	0.83	-0.10	-0.38
38°15'-14'	1.45	1.56	+0.11	1.57	+0.01	1.51	-0.06	1.49	-0.02	+0.04
38°14'-13'	1.50	1.80	+0.30	1.72	-0.08	1.58	-0.14	1.57	-0.01	+0.07
38°13'-12'	1.78	2.17	+0.39	2.18	+0.01	2.23	+0.05	2.24	+0.01	+0.46
38°12'-11'	1.46	1.76	+0.30	1.73	-0.03	1.70	-0.03	1.77	+0.07	+0.31
38°11'-10'	3.19	3.35	+0.16	3.26	-0.09	3.07	-0.19	3.19	+0.12	0.0

* Estimated.

to 38°15', did show a net loss of 0.38 km^2. This loss was countered by a gain of 0.57 km^2 in the next three segments. The total net change of island area within the study area south of the inlet actually increased by 0.37 km^2, a gain of 3 percent from 1849 to 1980.

Discussion

The pre-inlet (~1850 to ~1933) shoreline position change trends, along with island area measurements, indicate that significant migration of northern Assateague Island was occurring prior to the formation of Ocean City Inlet. Although the jettied inlet appears to have accelerated the rates of island migration, an underlying process is responsible for the historical trends. Some possibilities include subsurface lithologic control, oceanographic changes, and coastal construction.

Subsurface topography or lithologic variation may influence the behavior of barrier islands. Halsey (1976) indicated that Holocene barrier development was influenced by Pleistocene fluvial channels along southern Assateague Island. Davis, Hine, and Belknap (1982) found that the barrier islands of the west-central Florida Gulf of Mexico coast have stabilized above the edge of a westward sloping Tertiary bedrock surface. Several bedrock highs were also found beneath the barriers. Differential marsh compaction may also influence the geomorphic development of barrier islands. A proposed CERC vibracoring plan may indicate the effects of subsurface lithologic variation in the Ocean City area.

Several oceanic conditions may explain the Ocean City geomorphic changes. Goldsmith et al.'s (1974) study of wave refraction patterns along the Virginia Sea indicates a divergence of wave orthogonals in the Ocean City area. Waves approaching from the NNE and NE converge south of the inlet at 6 and 8 sec; whereas waves approaching from the E to SE converge north of the inlet at 10, 12, and 14 sec. These trends may indicate that erosional waves from winter storms affect the area south of the inlet more than they do from the north, and longer period swells, which may be accretional, affect the area north of the inlet more than they do from the south.

A reversal in the dominant direction of littoral transport south of the inlet is evidenced by accretion of sediment into the inlet channel across the south jetty (Dean and Perlin, 1977). This pattern could be compared to Hayes and Kana's (1976) model of transport reversal at the updrift end of a "drumstick" barrier island where the ebb tidal delta refracts incoming waves, causing the reversal. Increasing Holocene sea level may be complicating the effects of inlet dynamics and wave refraction.

Another possible explanation for the apparent stability of the island areas north of the inlet is the coastal construction in Ocean City. Groins, beach nourishment, and high rises in combination with the north jetty accretion may be providing an illusion of stability. Without these factors, southern Fenwick Island may have migrated landward along with northern Assateague. The high-rises and other buildings in Ocean City have prevented most overwash activity, which is essential for island migration.

Conclusion

Although the formation and stabilization of Ocean City Inlet has certainly altered the oceanic conditions in this area, a longer-term coastal process is at work. Significant shoreline recession, caused by barrier island migration, was occurring prior to the opening of the inlet. The inlet may be accelerating a natural process-response system. The ultimate cause of the observed trends, which is not known at this time, may be a complex combination of several factors.

ACKNOWLEDGEMENTS

The research presented herein was conducted by the Barrier Island Sedimentation Study Unit, Shore Protection and Restoration Program. Dr. Suzette K. May is the principal investigator for the work unit. Ms. Marie Ferland performed the field and analytical work for the New Jersey Study, and Mr. Kenneth Finkelstein was the scientist responsible for the Virginia Barrier Island field project. Mr. Stephen Knowles is developing the Ocean City/Assateague Island data base.

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DISCUSSION

DR. NUMMEDAL: You are doing a number of really interesting things. One thing I think that is extremely important to get out to the American public at large is mapping of the shoreline change that you're doing jointly with the National Ocean Service (NOS) because it's amazing how little people really know about the rates of change in shoreline location. So if there's anything that you can prioritize in completing that kind of study for at least the whole Atlantic and Gulf Coasts, it's extremely important. Also, there should be a way of getting it out to the public at large. Solving this problem is part of the Barrier Islands Resources Program that Congress is playing around with, and I think it would be a tremendous help to us, scientists, Congress, and everyone else if the actual factual data of shoreline change were available for anyone.

DR. MAY: Thank you. The point is well taken. NOS has recently, within the past year, reorganized. NOS has also established a special projects group which is responsible for handling the shoreline mapping project, and they are currently going to various state and local governments, to various other Federal agencies, to the geological surveys in various states, and to Corps Districts and Divisions. Any support along that line is helpful to them and to us in this effort. A measure of support from a local interest in terms of monetary or cooperative support will push that project forward even more quickly.

COL. HANSON: *Dr. Pilkey tells me that an Environmental Protection Agency (EPA) model predicts a 1- to 2-ft sea level rise in the next 50 years. Do you agree with that?*

DR. MAY: I personally think that the EPA model is somewhat extreme. During discussions with several representatives from EPA, they acknowledged that one of their main concerns was getting the information out into the public in a manner which would generate enough interest for feedback to give them the the impetus to keep going with the research. The research that they are sponsoring is very valuable, and there is a lot of very good work going on at a number of institutions. There are several groups that are also interested in this, not only EPA. NSF has just put out a publication on changing climates which addresses this issue. The Marine Board, of course, has been working with it.

One thing that you can say is there is no consensus. There are many, many different values for many different reasons, depending on who is looking at what. I would say that if one looks at the low range EPA estimates that they are probably valid for planning purposes. The high range EPA estimates will probably put you out of the realm of having to worry about it if they came true.

COL. HANSON: I like the 2 mm a year. I think that sounds great.

BG EDGAR: George.

BG ROBERTSON: *The logical next step, I guess, Dr. May, would be after you get your basic information on the evolution to attempt to control that evolution. Are you going to roll into this information on how to stabilize and how to develop barrier islands such as Fire Island in New York and Hatteras?*

DR. MAY: Well, the function of the group with which I work is to provide the basic geological information to the Districts and to our other branches who are involved with evaluating the design of structures and planning. We will provide information to Districts as requested about what the long-term evolution is, what our prediction is, what we give as the probability of a current and any of several scenarios on given levels of coastal processes.

Much of this information is being derived in order to give background to the modeling efforts here at CERC as well as to give that same type of background information to Districts as they request it. The group with which I work does not consist of engineers; we are not design people. All we can do is tell you what the long-term framework has been and what the likely response to severe--local events--might be.

BG ROBERTSON: *However, the more we understand the evolution the easier it would be for us to try to control that evolution, but you're saying that would go over to another group?*

DR. MAY: That's right.

DR. NUMMEDAL: *I wish to follow up on that question a little bit. You demonstrated to us two very different areas which are low, flat areas that roll over in a landward direction by washover and other low, flat areas that do seem to have a washover to develop in a landward direction. And I see exactly the same two types along the Gulf Coast. Are these two types randomly distributed in space, or is there some overriding pattern that can predict certain areas that should do so in terms of this evolutionary trend?*

DR. MAY: I don't have any hard figures to give you on that, but from what we have looked at I do not think that they are random. I think that there is an overriding control on the geological structures by the processes. In some cases, in the Virginia Barrier Islands, much of the positioning is determined by paleofluvial channels, and we see where a lot of the inlet form over old channels. We see a lot of channel deposits. I believe that that is a fundamental reason for some of what's happening. We often see the linear shoal fields. There's a control, an apparent control, on wave and current climate that results in not only these fields but also what's happening. So I think it's random. As far as a statistical pattern is concerned, we haven't evaluated that.

MR. PFEIFFER: *General Edgar, you triggered me and I'm going to point this one at Bob Whalin. Is there enough coming out of this, Robert, to perhaps influence Jim Houston's numerical model in a big sense and perhaps could it or should it influence our Coast of California storm and tidal waves work and our Coast of Florida work? Open question.*

DR. WHALIN: Well, maybe. How's that for an answer?

PROF. WIEGEL: A weak and strong maybe.

BG EDGAR: That's your open answer. Right, Robert.

DR. WHALIN: That's right. As we influence them, we're certainly going to take them into account is answer No. 1, of course. These folks do talk to one another. She works for Dr. Houston, so you know we're really into a policy question, when you're talking about sea level rise things. And I guess once we think we have a good enough handle on an estimate of it, then I'm sure our OCE folks will develop a policy on how to take that into account in the planning cycle.

I think that we're not taking it into account at the moment. Usually our projects have a 50-year life span. I've gotten a couple of letters, as a matter of fact, asking what our estimate is on that. But, yes, I think we're going to evolve very shortly to where we do take some position on how to take it into account in our planning site. The more we learn the closer we get to that, and it's very important; there's absolutely no doubt about that.

DR. HOUSTON: Dr. May is in the same branch as the people who are working on numerical modeling. I think you remember earlier in Dr. May's talk she mentioned a lot of the things she was doing in numerical on a long-term basis is passed on to the numerical modeling in that group. She's looking at a lot of things like sources, on sinks and sediments and that type of thing, sometimes in different time scales but a type we need to look at. So I guess the answer is "yes" to your question in the long term.

DR. MAY: *We have designed a series of experiments to be held in conjunction with those of a number of the other scientists here at CERC for the fall of 1985 and the fall of 1986, and in the specific experiments we have addressed the issues of sources of sediment, sediment transport direction, sorting, and the fine structures. When you look at the morphologic changes or bar/trough changes, are you looking at significant differences in composition? Or are you looking at merely a wave form on the bottom? That set of data is designed specifically to go into the fine tuning of the numerical transport models. We are not limited solely to long-term geologic processes. We're trying to help provide a data base for the models within the branch.*

EVALUATION OF NAVIGATION AND SHORE PROTECTION STRUCTURES

CERB Proceedings

Ms. Joan Pope
Research Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

A continuing work unit in the Coastal Structure Evaluation and Design Program, Coastal Engineering Functional Area, Civil Works Research and Development Directorate is described. This work unit, entitled Evaluation of Navigation and Shore Protection Structures, incorporates numerous individual tasks or projects. These tasks use field experience to evaluate and improve techniques employed for the planning, design, construction, and inspection of coastal structures. Small-scale monitoring activities and field tests are used to: (1) improve inspection and analysis methods, (2) document and interpret structure performance and sediment response to the structure, and (3) develop and improve design techniques. Current work is summarized. Example tasks such as investigating the use of airborne laser mapping for bathymetric surveying, developing field guidance for the use of side-scan sonar to inspect the underwater condition of coastal structures, monitoring detached breakwater projects and developing design guidance, monitoring large weir jetty projects, and evaluating the application and practical limitations of numerical models intended for coastal structure design and other work unit tasks are briefly discussed.

INTRODUCTION

The Coastal Structure Evaluation and Design Research Program includes Work Unit No. 31232, Evaluation of Navigation and Shore Protection Structures (ENSPS), which is a continuously funded research effort begun in the early 1970's. In the past, this work unit was the only mechanism by which the Corps of Engineers could monitor and evaluate the postconstruction condition of coastal projects. ENSPS was the forerunner of a national coastal monitoring program, Monitoring Completed Coastal Projects (MCCP) Program. As a result of the initiation of the MCCP Program and the slowly evolving trend of Corps Districts to conduct postconstruction monitoring, the role of ENSPS as the Corps' sole coastal monitoring vehicle diminished.

ENSPS has been redefined to directly address the need to improve techniques used to plan, design, construct, and inspect coastal structures, based on field experience and the performance of actual projects. The three main objectives of ENSPS are to:

(1) Improve prototype monitoring, inspection, and analysis technology.

(2) Document and interpret structure and sediment interaction.

(3) Develop and improve design techniques to improve structure stability and efficiency.

To accomplish these objectives, ENSPS has been tailored to complement MCCP and other research programs by developing design information from the results of individual field tests and a number of monitoring programs. Particularly valuable elements of a project ("targets of opportunity")--small-scale field data collection, technology verification tests, and cooperative monitoring programs--are documented, evaluated, and interpreted for general coastal engineering application.

ENSPS is used to promote technology transfer between coastal research activities and between the field and the research community. Field data can be collected to develop physical and numerical simulation theory. The resultant models can then be verified relative to documented prototype cases. Additionally, theoretical design criteria can be tested under real conditions and improvements recommended, and gaps in design practices can be identified. Finally, research discoveries can be adapted for general field use.

Each task currently addressed under ENSPS is of individual interest and deserving of independent reporting. Although each task is explored only briefly here, a sequence of developmental reports will be produced for various levels of field and technical use. Below is a list of current work under ENSPS.

(1) <u>Inspection and Analysis Methods</u>

- (a) Airborne Laser Mapping
- (b) Side-Scan Sonar
- (c) Comparison Analysis of Survey Data
- (d) Digitized Analysis of Survey Data
- (e) Revised LEO Methodology (DUCK '86)
- (f) Statistical Analysis of Sediment Data

(2) <u>Structure Performance Documentation</u>

- (a) Detached Breakwater Monitoring--Lakeview Park, Ohio; Lakeshore Park, Ohio; and Colonial Beach, Virginia
- (b) Weir Jetty Monitoring--Murrells Inlet, South Carolina and Little River, South Carolina

(c) Tybee Island History of Shore Erosion and Protective Structures

(d) Monitoring Seawall Effect on Beach Profiles

(3) Design Technique Development and Improvement

(a) Sand Sealing of Jetties

(b) Shallow-Water FTB Testing

(c) Detached Breakwater Design Guidance

(d) Evaluating Application of Numerical Models for Structure Design
(1-Line for Lakeview Park)
(Field Testing of N-Line)

(e) Engineer Manual on Beach Erosion Control Structures

(f) State-of-the-art Seawall Design

INSPECTION AND ANALYSIS METHODS

Efforts to evaluate the level of success of a coastal project are limited by the cost of data collection, the need for long-term documentation, and uncertain interpretations of the results. ENSPS tasks are aimed at improving the efficiency and decreasing the cost of field data collection and establishing procedures for data reduction. A number of these tasks are summarized below.

Airborne Laser Mapping

Airborne laser mapping systems have considerable potential for providing bathymetric data to water depths of 10 m or more with adjacent beach area topography. Preliminary experiments have demonstrated resolutions on land of approximately 12 cm and 30 cm in water. Two major concerns are (1) that water turbidity limits laser penetration and (2) position control of the aircraft limits the accuracy of the resultant project data. The potential to quickly obtain digitized, large-scale profile data is very attractive. Tests of a commercial system and the more sophisticated Navy/Defense Mapping Agency HALS system have been conducted at the Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF). In addition, a contract with the National Aeronautics and Space Administration (NASA) has recently resulted in a review of "off the shelf" laser mapping equipment and capabilities. As a result of terrestrial tests, Navy/NASA bathymetry mapping tests, and research conducted under ENSPS, a complete test of airborne laser mapping as a tool for coastal surveying may be conducted under a remote sensing demonstration project.

Side-Scan Sonar (SSS)

SSS is the only commercially available tool which can be used to rapidly document underwater features where direct visual inspection is not feasible. SSS allows rapid, cost-effective, and safe qualitative surveys of the bottom and structure conditions. Applications are numerous and include finding lost objects, locating channel obstructions, performing geologic mapping, inspecting the submerged portion of existing structures, and providing quality control of contract construction (Patterson and Pope, 1983). A Klein Model 530, 500-kHz SSS system is available at CERC and has been used on a number of field tests which explore the application of this technology in the coastal zone. Noteworthy field tests have been conducted for the dolos rehabilitations of the East Breakwater in Cleveland Harbor, Ohio (Pope and Clark, 1983) and at Manasquan, New Jersey; to locate and define the condition of a Civil War period timber structure at Alexandria, Louisiana; to perform quality control of underwater stone placement at Ocean City, Maryland; to monitor the distribution of dredged material at Dams Neck, Virginai; and to evaluate the effectiveness of new techniques for underwater disposal of contaminated dredged material at Seattle, Washington. These and other tests have demonstrated that various manipulations to the system can be used to enhance the image and add perspective to the object under investigation, thus aiding in the interpretation of even complex underwater features.

Comparisons of Survey Methods

Tests have been conducted at the FRF to compare four different survey methods. Results from standard hydrographic fathometer surveys, the CERC sled, and the Scripps hydrostatic profiler were compared to direct measure results obtained with the Coastal Research Amphibious Buggy (CRAB) (Clausner, Birkemeier, and Clark, in preparation). Test results demonstrate the ability of the two newer systems to provide significantly higher accuracy and repeatability in the surf and nearshore zone than a standard hydrographic survey system. The survey concluded that the CERC sled was the most practical tool for high quality nearshore surveying.

Digitized Analysis of Survey Data

Although survey data are often collected, they involve lengthy data reduction and analysis prior to producing information on areal changes and quantities of sediment movement. Through the use of an electronic digitizer, a data base of both bathymetric and topographic survey plots can be created and then evaluated to produce contour maps, contour maps of change, profiles, and three dimensional (3-D) plots, and, finally, to compute changes in areas and volumes. This technique is being applied to study the long-term bathymetric and shoreline changes in the vicinity of Charleston Harbor, South Carolina, and to evaluate survey data produced through various monitoring programs conducted under ENSPS.

Revised Littoral Environment Observation (LEO) Methodology

LEO is a very valuable tool for rapid and inexpensive data collection on local coastal processes (Schneider, 1981). However, during the approximately 15 years since inception of the LEO program, a number of problems have been identified in the attempt to obtain accurate and consistent data. Interpreting the significance of the resultant data may also be a problem. In order to revise LEO methodology, a series of tests will be conducted over the next 2 years, including a major research effort during the DUCK '86 project at the FRF in the fall of 1986. At that time, suggested revisions in observer training, data collection instrumentation and techniques, and data analysis will be tested. The expected result of this study will be revisions to the LEO program which should improve the scientific value of observer-collected wave and current data.

Statistical Analysis of Sediment Data

Sediment samples are frequently collected as a part of most monitoring programs and in support of the design of recreational beach projects. However, the analysis of sediment data is typically qualitative because of difficulty in directly comparing gradation curves. By utilizing the statistical technique of cluster analysis, sediment samples can be analytically grouped. A series of characteristic gradation curves is developed from the entire population of sediment samples, and each sample is assigned to its representative group or cluster. This allows ease of mapping and can be used to illustrate temporal and spatial changes in sediment composition. Statistical analysis of sediment data through cluster evaluation has been successfully applied to Lakeview Park, Ohio, and Homer Spit, Alaska.

STRUCTURE PERFORMANCE DOCUMENTATION

Functional structural behavior and the effects on beach bathymetry and topography are documented for selected projects or portions of projects.

Emphasis is placed on monitoring small-scale, rapidly responding projects or unusual situations as they evolve. Projects having interest to other parties are cooperatively monitored. Whereas the MCCP Program will monitor many aspects of a large-scale project under a specific format, ENSPS will isolate project features of interest and group similar projects to resolve specific design concerns. ENSPS provides the Corps with a mechanism for evaluating structural successes and failures and for communicating those results.

Recent monitoring programs have included detached breakwater projects and the immediate postconstruction effects of large weir jetty projects. Studies under development now include monitoring the effect of seawalls on beach fill and on low-cost forms of shore protection.

Detached Breakwaters

At present, there are only six documented detached breakwater projects in the United States (Dally and Pope, in preparation). Three of these projects are being monitored under ENSPS. Lakeview Park, Ohio; Colonial Beach, Virginia; and Lakeshore Park, Ohio. Two of the other detached breakwater projects--Presque Isle, Pennsylvania (Gorecki, 1985) and East Harbor, Ohio--are being monitored by local sponsors, US Army Engineer District, Buffalo and the State of Ohio, respectively. The sixth detached breakwater project is Winthrop Beach, Massachusetts, which was constructed in 1935 and has long since established a stable beach planform.

Detached and segmented breakwaters have seen significant use as beach erosion control devices in other countries, but there has been a general reluctance in the United States to build breakwater projects without design guidance and proof of success. Through the monitoring of various projects, guidance and confidence are developed which should promote a high degree of future success.

The Lakeview Park, Lorain, Ohio, project was constructed in 1977. It consisted of placed beach fill, two terminal groins, and three detached breakwaters. A 5-year cooperative monitoring and evaluation program was established by the Buffalo District and CERC (Pope and Rowen, 1983). A reduced level of monitoring has continued since 1982. The placed fill adjusted rapidly to a morphology which was approximately balanced with the structure configuration. However, the beach exhibits distinctive seasonal trends and is modified by changes in water level. Through the Lakeview Park project, much has been learned about the rate and nature of sediment and structure interaction. The data collected from Lakeview Park are also being used to improve our data analysis technology and to test various predictive design tools.

Two sites, approximately 1.5 km apart, are protected by detached breakwaters at Colonial Beach, Virginia (Dally and Pope, in preparation). Seven detached breakwaters were constructed in 1982 on the Potomac River estuary to protect placed beach fill, creating recreational beaches. Although local fetch is small, the area is susceptible to tidal fluctuations and storm surges which periodically submerge the breakwaters and the beach. In contrast to the two other detached breakwater projects which are being monitored, Colonial Beach frequently experiences tombolo development. A cooperative monitoring program is currently being conducted by the Baltimore District and CERC.

In 1982, three detached breakwaters and a placed beach-fill project were constructed at Lakeshore Park in Ashtabula, Ohio (Bender, 1985). The project site is isolated from outside littoral sources by neighboring structures and experiences a relatively narrow range of incident wave angles. A cooperative monitoring program is currently being conducted by the Buffalo District and CERC. This beach has not attained a stable sinuous planform, is gradually losing beach width; beach fill appears to be leaking out of the project to the west. Preliminary investigations suggest that the initial beach fill was too fine grained, that the breakwaters may be too far offshore for such a short period wave dominated site, and that local coastal currents may generate sediment movement. Monitoring of this project is adding another very significant dimension to our understanding of detached breakwater design.

Weir Jetties

The effect of large navigation structures on sediment distribution patterns has been well illustrated through supposition, but data which document sediment response to such structures during the very important postconstruction adjustment period are very rare. Two weir jetty navigation projects are being cooperatively monitored with Charleston District under ENSPS. Jetties at Murrells Inlet, South Carolina, were built during 1977-1980, and jetties at Little River, South Carolina, were built during 1981-1983. In many ways these are twin projects because the same structural configuration can be compared for the two different site conditions.

The first 5-year phase of a 10-year monitoring program was completed at Murrells Inlet in 1982 (Douglass, in press). Preconstruction Murrells Inlet was an ebb tide dominated tidal inlet which had historically migrated both north and south into adjacent barrier beaches. Major features of the project are two approximately 1,050-m-long jetties, a dredged navigation channel, a weir section in the north jetty, a depositional basin, and beach nourishment areas. Although development of the data base will continue through 1987 and analysis of data collected to date will continue for many years, the monitoring and evaluation program has already been used to develop future maintenance programs and has revealed dramatic details about the interrelationship of coastal structures, longshore transport patterns, wave climatology, and tidal delta response. One of the most significant results of the monitoring program so far has been the documentation that these, not particularly long, jetties have affected coastal processes and the resultant beach planform over a number of miles.

The Little River project was designed to the same basic plan as the Murrells Inlet project but is located approximately 35 miles to the north. The longshore transport regime at the Little River site was thought to be more equally balanced than at the Murrells Inlet location, so a weir jetty was constructed in both jetties but then temporarily sealed. This would allow maintenance and sand-bypassing to be accomplished in either direction in response to random fluctuations in the littoral regime. A monitoring program similar to that conducted at Murrells Inlet has been initiated, and similar trends are already being observed.

DESIGN TECHNIQUE DEVELOPMENT AND IMPROVEMENT

Several tasks are being developed to improve design techniques and transfer information on successes and failures to the field. Lessons learned from monitoring programs and field tests conducted under ENSPS or other research programs and from documented field experience are summarized. These lessons are then translated into general planning, design, or construction guidance. Some of the current work under this objective has been previously discussed. For example, guidance is being developed to assist the coastal engineer in designing detached breakwaters and other beach erosion control structures. Also, a report is being prepared to document applications of SSS in the coastal zone.

Sand Sealing of Jetties

Various Corps Districts have requested guidance on how to construct or modify an existing jetty to make it impervious to sand. The movement of sand through a permeable jetty can add significantly to channel shoaling rates and increase dredging costs. In some cases, the movement of sand through a jetty causes an unretrievable loss of littoral material and increased beach erosion. Techniques employed for sand sealing include driving sheet pile, laying filter cloth, overbuilding the jetty to accommodate a larger fine-grained core, building a low permeability rubble-mound dike adjacent to the original structure, injecting grout, and even using explosives to reduce the grain size of the core material and reduce structure permeability. Through ENSPS, jetties which have been sealed will be inventoried and, an analysis will be made of the successes, failures, and lessons. Eventually, these data will be supplemented with newly developed technology to develop design guidance.

Shallow-Water Floating Tire Breakwater Test

In 1978 a Goodyear Plan floating tire breakwater (FTB) was installed at Pickering Beach, Delaware, in Delaware Bay. The Pickering Beach FTB was constructed through the Section 54 Shoreline Erosion Control Demonstration Program by the Philadelphia District and the State of Delaware. By 1979, movement of the anchor blocks had caused serious deformation of the FTB, forcing complete reinstallation. The Pickering Beach project continued to exhibit inadequacies in the anchoring system design; and a totally new anchoring system, utilizing driven piles, was installed in 1980. Preliminary data from the Prototype Floating Breakwater Project in Seattle, Washington, indicated that anchoring forces on this deepwater (approximately 40 ft) installation are relatively small. The anchoring problems exhibited by the shallow-water Pickering Beach FTB suggest the opposite is true for this installation. Therefore, a cooperative 1-week field test is programmed to be conducted this fall by CERC, the Philadelphia District, and the State of Delaware. A large vessel will be used to generate boat wakes. The incident and transmitted waves as well as the mooring forces, will be measured.

Numerical Models for Structure Design

Several types and generations of shoreline and/or sediment response numerical models have been developed in recent years which promise to revolutionize the art of developing a functional design for beach erosion control structures. However, models are based on theoretical attempts to predict the complex processes of the nearshore and therefore have limitations which need to be defined. Field verification of the basic model theory is necessary before widespread design application can occur. In addition, guidance for selecting the input parameters needs to be developed. An N-line model (Perlin and Dean, 1983) developed under another research program is being tested using prototype information from Lakeview Park. Results and suggestions for revising the Users Manual have been summarized. In addition a 1-line model (Kraus, 1983) has been developed for Lakeview Park, and verification testing is under way. By applying numerical models to well-documented projects, we can test the model's sensitivity to a variety of real world conditions and define design limitations.

SUMMARY

Projects which are incorporated into ENSPS attempt to fulfill District level needs. They are typically cooperative, short-term, inexpensive tasks which document successes and failures. Traditionally there has been a lack of communication regarding projects that have worked well. Costly mistakes are sometimes repeated. Unless the reasons for the success or failure of a project are identified, coastal engineering does not advance, and our products will not improve. ENSPS functions as a mechanism for the transfer of coastal data, technology, and information.

ACKNOWLEDGEMENTS

No research effort of this magnitude can be implemented by one person. The following individuals have contributed or are contributing greatly toward the accomplishment of the described tasks: Michael Andrews, John Bartholomeo, Thomas Bender, William Birkemeier, Denton Clark, James Clausner, Julie Dean, Scott Douglass, Ed Fulford, Peter Grace, Mark Hansen, Ted Hauser, Nicholas Kraus, Thomas Richardson, Darlene Rowen, and Jeffrey Thomas.

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DISCUSSION

PROF. WIEGEL: I want to thank you very much for a very thorough presentation on a subject that we have been pushing for some time and that is to recognize that the full scale--the actual conditions--are what we have to spend more of our time looking at and getting our data from. And I agree with the comment that you made that we really knew very little about the effects of some of these walls--be they concrete or rip rap--on whether or not a beach eroded.

And we have seen examples. We saw one up in Lake Michigan when we were up at the Chicago meeting where putting in a seawall seemed to cause accretion, not erosion, in front if it. General Berrigan has just written an article on a San Francisco seawall which, for reasons which are certainly not clear to most of us, has caused accretion. I think, hopefully, there will be increased effort along the lines of the work that you've been presenting here. I really think we've got to do more of this, and again I want to thank you for it.

DR. NUMMEDAL: *You showed a map. I think it was from Lakeview Park in Ohio where you showed two different sediment populations, one that was spreading over the other, and based on the grain size distribution I was thinking of Mr. Murden's proposal yesterday about building the submerged berm. Do you think that you could use a similar analysis like that as a way of mapping the migration of that material?*

MS. POPE: I think that's an excellent idea. The first time we applied this technique was for Lakeview Park. Since then--and General Robertson will appreciate this--we've also applied it to Homer Spit, and it worked very well there also. Before we really promote this in the field as a technique which has a lot of potential, we'd like to apply it in some areas where the grain size is very uniform to see how small a grain size difference we can discriminate. The main thing that's important is you must have a good population of data. You need at least a hundred samples in order to develop the three or four, maybe five, clusters that are appropriate to really define the different energy regimes and sediment populations.

MR. OLIVER: I'd be very willing to volunteer some of our dredged disposal sites in the North Pacific Division where sediments that we're dumping or disposing of are very similar in grain size to the background material. In fact, this is a target of opportunity. We're doing some studies there now.

MS. POPE: Very good. We'll talk about it later.

MR. OLIVER: Okay.

"DUCK '86" FIELD EXPERIMENT

CERB Proceedings

Dr. Nicholas C. Kraus
Research Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The Coastal Engineering Research Center (CERC) is planning a large-scale cooperative field data collection project on nearshore processes. The project, called "DUCK '86," will take place over an approximately 1-month period in the autumn of 1986 at CERC's Field Research Facility (FRF) located at Duck, North Carolina. Data will be collected on the winds and waves, nearshore and coastal circulation, sediment transport, and beach morphology change. Storms can be expected at the FRF from about mid-September, affording the opportunity to do experiments in either moderate or storm weather conditions. The objective of the project is to obtain a comprehensive and high quality data set on nearshore processes to improve Corps of Engineers design techniques in the nearshore region. The approach is to make a cooperative joint effort using shared resources of the FRF and individual investigators. A project management structure has been created to coordinate efforts of CERC investigators and investigators from other organizations.

INTRODUCTION AND BACKGROUND

It is well recognized that both understanding of basic physical nearshore processes and capability to measure them are far from satisfactory. In some research areas, theoretical developments have advanced beyond the data available to make verification, as in the case of the longshore current and nearshore circulation. In other areas, such as sediment transport anywhere in the nearshore zone and fluid motion in the swash zone, accurate and reliable measurement devices do not even exist. Major advances in knowledge of nearshore processes for engineering use will result from improved field instrumentation and experiment designs applied to obtain quality field data on basic physical mechanisms as well as data on quantities of direct applicability to coastal engineering.

In the past decade, the concept of joint field experiments performed by cooperating investigators from several organizations has proved successful for obtaining quality data in the nearshore zone. Cooperative and coordinated experiments performed by several investigators using shared resources are necessary in order to obtain synoptic and simultaneous measurements of all important parameters relating nearshore forcing functions and their responses. A number of multi-institutional data collection efforts have been undertaken in the nearshore zone, examples of which are:

(1) USA: Nearshore Sediment Transport Study (NSTS), (Seymour and Duane, 1979; Seymour, 1983).

(2) Japan: Nearshore Environment Research Center Project (Horikawa and Hattori, in press).

(3) The Netherlands: Field Campaign Egmond, (Derks, et al., 1984).

Also, in the past decade, significant advances have been made in electronic measurement instrumentation and general field experience and "know-how." Rapid progress is continuing in the development and adaptation of devices for measuring winds, waves, currents, sediment transport, and beach bathymetry in various distinct regions of the nearshore zone, such as the swash zone, surf zone, and offshore.

Birth of DUCK '86

It was with this backdrop that CERC investigators first met in October 1984 to begin planning of a large-scale cooperative field data collection project to meet their needs for improving design techniques.

The FRF was chosen to be the project study area. The FRF is located on a 175-acre site at Duck, North Carolina (Figure 1). Main facilities are a 561-m-long research pier, laboratory and office building, minicomputer, Coastal Research Amphibious Buggy, and an instrument sled. Local and deepwater wave conditions are routinely measured, and highly accurate profile surveys are made at weekly intervals. Special effort is made to obtain beach profiles before and after storms. A number of major field efforts have been carried out at the FRF (Table 1). Thus, there is a wealth of background data available to provide baselines for experiments at the site. This baseline data, coupled with the experienced and professional technical support available from the FRF staff, made Duck the logical choice for this first CERC-wide cooperative data collection effort on nearshore processes.

It was estimated that 2 years would be necessary to test new or modified equipment and procedures and to establish an overall structure for the complex project. Since some experiments would be performed under moderate wave conditions and other experiments under storm conditions, the period of September to October, in which northeasters can occur, was selected. Thus the location and schedule for the project "DUCK '86" evolved.

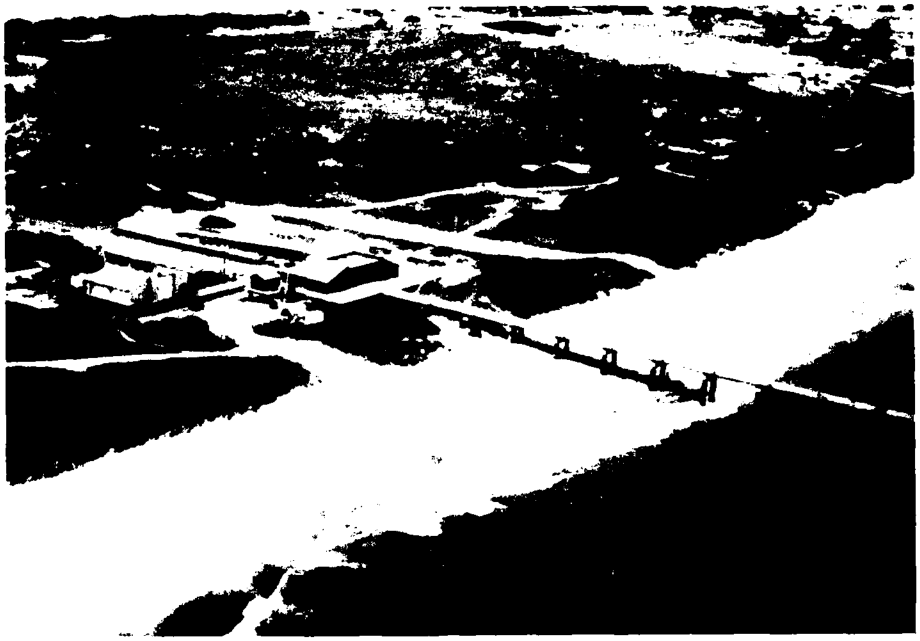

FIGURE 1. FIELD RESEARCH FACILILTY (FRF)

TABLE 1
MAJOR EXPERIMENTS HELD AT THE FRF

Year	Project	Purpose
1979	DUCK X	Ground truthing of seasat satellite; wave measurements
1980	ARSLOE	Wave transformation (CERC, National Oceanic and Atmospheric Administration (NOAA); 31 agencies)
1981	A-SEX	Survey of active shore face (CERC, United States Geological Survey (USGS), University of Georgia)
1982	DUCK '82	Storm-induced nearshore bottom change (CERC, USGS, Oregon State University, and University of Washington)
1985	DUCK '85	Trial for DUCK '86
1986	DUCK '86	Comprehensive data collection on nearshore processes

A related smaller scale project will take place at the FRF in the first 3 weeks of September 1985. Its principal purpose is to provide a trial for testing and refining equipment and experiment designs prior to full deployment at DUCK '86. Some specific complete experiments will be performed to take advantage of the FRF routine data collection program and whatever data are collected in the field measurement testing.

PROGRAM MANAGEMENT

Steering Committee

A steering committee was formed to provide overall guidance for the project and to serve as an initial contact source for prospective investigators in organizations other than CERC. The steering committee is comprised of the following persons from CERC, each having considerable experience in large-scale beach experiments: Dr. William L. Wood, Chief, Engineering Development Division; Mr. Curt Mason, Chief, FRF, and Dr. Nicholas C. Kraus, Coastal Processes Branch, Research Division. Figure 2 presents an organization chart of the various committees and groups of which the management structure is composed.

Planning Committee

The CERC Planning Committee has the responsibility of assisting individual investigators in the planning of their experiments and of coordinating all experiments, including those of non-CERC investigators. The CERC Planning Committee is chaired by Mr. Thomas W. Richardson, Chief, Coastal Structures and Evaluation Branch, and its members are Mr. William Birkemeier, FRF; Mr. Gary Howell, Prototype Measurement and Analysis Branch; Drs. Jon M. Hubertz and Steven A. Hughes, Coastal Oceanography Branch; and Drs. Suzette K. May and Lee L. Weishar. The Planning Committee has had several meetings to discuss project goals and structure, experiment design and coordination, equipment and manpower requirements, and many other details associated with a project of this scale.

Experiment Areas and Managers

Proposed experiments were separated into four groups according to their major emphasis, and a coordinator for each group was designated from among the Planning Committee members. A fifth group, Data Management, was added because of the need to coordinate data recording resources during the course of the

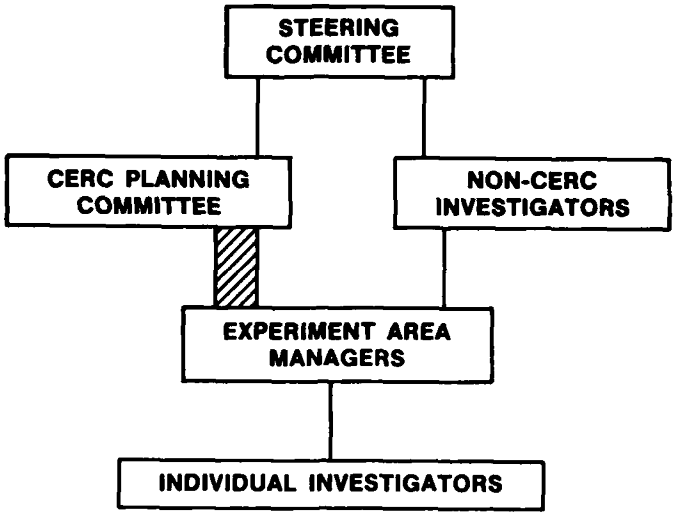

FIGURE 2. MANAGEMENT STRUCTURE FOR "DUCK '86"

project and to facilitate data sharing at the analysis stage. The groups and their managers are:

(1) Group I - Waves and Wind (Hughes)
(2) Group II - Currents (Hubertz)
(3) Group III - Sediment Transport (Weishar)
(4) Group IV - Geomorphologic Change (May)
(5) Group V - Data Management (Birkemeier)

OVERVIEW OF EXPERIMENTS

A summary of all experiments proposed to date by CERC investigators is given in Appendix C. The summary is organized according to group. In overview, 16 experiments have been proposed. Six experiments are cooperative efforts among CERC personnel of different branches. Three experiments will be performed jointly with non-CERC investigators. It is expected that a limited number of experiments will be added after the project is announced publically in the June 1985 edition of the CERCular.

Within each group, experiments that are seen as major efforts, performed to collect data directly related to the subject area of the particular group, were designated as "core" experiments. Core experiments are aimed at acquiring data of immediate use to principal investigators of CERC research work units, and they will provide much of the supporting data needed by experiments of more limited scope.

Example Experiment

As an example, the author's experiment will be outlined. This is experiment III-1 under the Sediment Transport group listed in Appendix C. The purpose of the experiment is to measure the time-mean cross-shore distributions of the longshore and cross-shore sediment transport rates in the surf zone by means of traps. It is a core experiment because data collected will be of direct use to the Numerical Modeling of Shoreline Response to Coastal Structures work unit. It will also provide "absolute measurements" for comparison to data collected by electronic sediment movement sensing devices. Experiment III-1 will use the data from current meters and pressure gages located in shallow water in experiment II-1 (wide-scale nearshore current pattern) and the breaking wave data obtained in experiment I-3 (wave transformation in the nearshore zone).

The current data collected in the sediment trap experiment will supplement the data collected in experiment II-I on the nearshore current, providing a complete data set on currents in the nearshore zone. These two experiments were, in fact, planned to augment and complement each other.

It is probably beyond the financial and manpower resources of an individual investigator to collect such a comprehensive set of data on waves, currents, and sediment transport for even this small subset of experiments which will be performed at DUCK '86. The value and efficiency of carefully planned cooperative joint field data collection efforts are clearly demonstrated in this example.

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DISCUSSION

DR. LE MÉHAUTÉ: *I'm sure you're familiar with NSTS (National Sediment Transport Study)?*

DR. KRAUS: Yes, I am.

DR LE MÉHAUTÉ: *What you're planning to do at Duck, is it more or less what was done at NSTS? Or is it different? Will it be better?*

DR. KRAUS: Of course. There's no question about that. I feel I'm on delicate ground. I was not inside NSTS, so I'm open to attack; but my feeling is that what we are doing and what we did in Japan is considerably more engineering oriented than what was done at NSTS. Secondly, the experiments are being designed mainly to address problems in CERC work units. They are not "pie in the sky" ventures. Our plan is to attack problems that researchers are having and perhaps can't get to on individual reimbursable projects or research projects at Duck. We can use joint resources and attack problems together.

Finally, one other component is we are hoping for some storm change and some storm related processes; and I don't believe NSTS was directly looking for that.

DR. LE MÉHAUTÉ: They did by sediment trapping in Santa Barbara.

PROF. WIEGEL: *Yes, I think it's a real good idea what you're proposing, and I am glad to hear about it and want to see it proceed. Some years ago I was in Poland, and up in the Baltic there was a similar intense effort of this sort with a series of engineers and scientists form Poland, East Germany, Bulgaria, the USSR, and Latvia. They had a number of wave recorders, current meters, and the simpler sediment sampling system throughout the water column. They rushed people down to take core samples throughout the sand and made studies of the mineralogy of it. Have you seen that, or has anyone here seen the outcome of it? There may be things there that would help you avoid pitfalls.*

DR. KRAUS: Taking your comment in sort of reverse order, we have looked. For example, Dr. Wood was involved inside NSTS while I was in the NERC project, and we certainly are factoring in our experiences. Also there has been a project recently that is ongoing in the Netherlands. It's on a considerably smaller scale, but it is a joint effort. Concerning the Polish experiment, I also have seen hints of that in a little bit of offbeat literature, not the mainline coastal engineering literature, and I can imagine there is more out there. I have not seen a monograph or a summary or wrap-up of that experiment.

DR. WIEGEL: I'll see if I can get it. I was there at the time, and it was a massive but a first-rate effort. The people were good.

DR. WHALIN: I'm personally not familiar with it.

DR. KRAUS: I do have a foot into Poland through Sweden--a colleague there--and I will look into that.

BG EDGAR: I believe General Palladino has a few words.

BG PALLADINO: There are a couple of items which are outstanding and for which I feel some responsibility. The first relates to the discussion we had in Chicago on fiber reinforcement of concrete armor units. In view of the material we sent out following that meeting, informal as well as formal presentations, I consider that issue closed, except obviously for the continued observation of the concrete armor units at Crescent City and other locations.

BG EDGAR: I agree with that.

BG PALLADINO: Secondly, we had an outstanding invitation to the civilian members of the CERB to visit California and review in more detail the Coast of California Storm and Tidal Wave Study. I would like to set 20 June as the date for that meeting in Los Angeles. I believe that has been agreed on by all the members, and we'll look forward to seeing you in California on that date.

BG EDGAR: Good.

BG PALLADINO: The second item is I would just like to express my appreciation for a very fine program. I think the presentations and the discussions were extraordinarily beneficial, and I commend the CERC staff and all the presenters for their fine work. I think it was very valuable for CERB to meet here at this time. And I would also extend that thanks to those, both in CERC and at the Station, who provided all the administrative support in the arrangements for this particular meeting.

Along that line, Mr. Ace Wanket tomorrow, on the schedule, will make the presentation concerning a joint venture between North Pacific Division (NPD) and South Pacific Division (SPD) to have a regional conference in San Francisco the first week in November. We hope that that can be accompanied by a meeting of the CERB during that same time frame so that the coastal community can gather in San Francisco at the bay model, first for a CERB meeting and then following for a jointly sponsored NPD, SPD, American Society of Civil Engineers regional coastal conference. Obviously I support that endeavor and would welcome the opportunity to see you in California.

BG EDGAR: Thank you.

PROF. WIEGEL: *First week in November?*

BG PALLADINO: Yes, sir.

BG ROBERTSON: We would like to have the Board stay over as much as possible for a full week of time devoted to coastal research and interests.

COASTAL FIELD DATA COLLECTION PROGRAM

Mr. J. Michael Hemsley
Research Hydraulic Engineer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Dr. C. Linwood Vincent
Research Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Mr. Paul F. May
Research Physical Scientist
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

Long-term data bases that encompass winds, waves, currents, water levels, historic trends in shoreline position, variability in beach profile and bottom configuration, sediment characteristics, and geomorphologic data are inherently required for the planning, design, construction, operation, maintenance, monitoring, and evaluation of Corps of Engineers (Corps) coastal projects. This information is often required to evaluate permit requests as well. However, data are either unavailable in existing archives, of uncertain or poor quality, or too sparsely distributed temporally and/or spatially to have statistical viability. Project planning, engineering, or operation must, therefore, use questionable or incomplete data that result in overly conservative and expensive designs or in inadequate designs that will require inordinate operations and maintenance expenditures. In 1976, the Corps established the Coastal Field Data Collection Program in an effort to provide the data required by the Corps' coastal professionals in their jobs.

INTRODUCTION

Funding for the Coastal Field Data Collection Program (CFDCP) was first provided in FY 1976, initiating an ambitious program to collect data needed by the Corps' coastal professionals. In 1982 the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES) was given the responsibility for managing the CFDCP. According to the provisions of Engineer Regulation 1110-2-1406, CERC's mission was to "...conceive, plan, and conduct a coastal data collection program on a nationwide basis to meet long-term Corps of Engineers (Corps) needs." The necessity for these data was clearly delineated in the regulation (Headquarters, Department of the Army, 1981) as follows:

> Long-term statistical data on physical environmental parameters, such as the wave climate, the erosion and/or accretion rates along the shore, coastal currents, topographic changes, and the location and amount of sand resources, are needed for coastal navigation, hurricane, flood, and storm protection, and beach erosion control project planning, design, construction, operation, and maintenance.

To accomplish this mission, a data acquisition program composed of multiple tasks, each of which was designed to acquire certain generic types of data, was formulated. These tasks, discussed below, are contributing significantly to the Corps' mission in coastal planning, design, construction, operation, and maintenance.

FIELD WAVE GAGING

While the timely collection and reporting of climatological and environmental data have become routine in many countries, a similar capability for waves, currents, and coastal winds has not. The need for long-term, high quality wave data, in particular, has long frustrated the coastal engineer. In 1974, both Professor Robert Wiegel and Dean Morrough P. O'Brien commented publicly on the need for information on the nearshore wave climate comparable to data routinely available on many other natural phenomena. O'Brien further expressed his concern for improving the accuracy of wave forecasting and hindcasting techniques through comparison with reliable measurements (Edmisten, 1978).

The need for characterizing the nearshore wave climate is much like the experience of conventional meteorological measurement programs. Along coastlines with high population densities, usage of the resource is intense. Ignorance of the processes at work carries a significant penalty. Past programs either have emphasized the collection of deepwater wave climatology or have been too regional or even site specific. With the Field Wave Gaging Program (FWGP), the Corps intends to collect the long-term, nearshore wave data that are necessary for planning, design, construction, operation, and maintenance of coastal projects.

History and Objectives

In 1974, the American Society of Civil Engineers sponsored the

Conference on Ocean Wave Measurement and Analysis. As a direct result of that conference, Scripps Institution of Oceanography installed a regional wave monitoring network for the State of California in 1975. The network began modestly, with only four stations operating by mid-1976, supported by the California Department of Boating and Waterways (Cal Boating) and the National Oceanographic and Atmospheric Administration (NOAA) Sea Grant Program. In 1978, the South Pacific Division (SPD) became involved and provided funding to begin the expansion of this network throughout California. The Coastal Data Information Program (CDIP) became a cooperative effort between the Corps and Cal Boating, with Scripps acting as a contractor for data collection, analysis, and reporting (Seymour, 1979).

Almost concurrently with the foundation of the CDIP, the Corps established the nationwide CFDCP, one element of which was the FWGP. The goals of the FWGP are to collect nearshore and relatively deepwater wave data to satisfy the immediate needs of the coastal planner, designer, and project operator; to support the Corps' effort to develop a wave hindcast/forecast model; and to provide a long-term data record for all of the nation's coastlines.

The existence of the CDIP has been very beneficial to the FWGP in two ways: (1) by having begun development on the automated data collection, analysis, and reporting system, and (2) by establishing a network of CDIP gages to provide a starting point from which the national wave gaging system could expand.

Gage Network

Eventually, the FWGP will acquire wave data along each of the Nation's coasts. Primary data for the program will be collected at a number of deepwater or index sites (Figure 1). These stations will be operated continuously in order to provide reliable long-term statistical wave data for use in planning, design, operation, and maintenance of coastal engineering projects. They are located in water sufficiently deep to minimize bathymetric effects on the measured waves, often as deep as 200 m (650 ft). An additional and unfortunately critical consideration in siting the index gages is to find a location that is not in a commercially fished area. Commercial fishermen using bottom-dragging equipment can break a deepwater mooring with their nets. This is an all too frequent occurrence in commercial fishing grounds even though instruments are reported in the US Coast Guard "Notice to Mariners."

Augmenting the index stations are nearshore gages located in areas

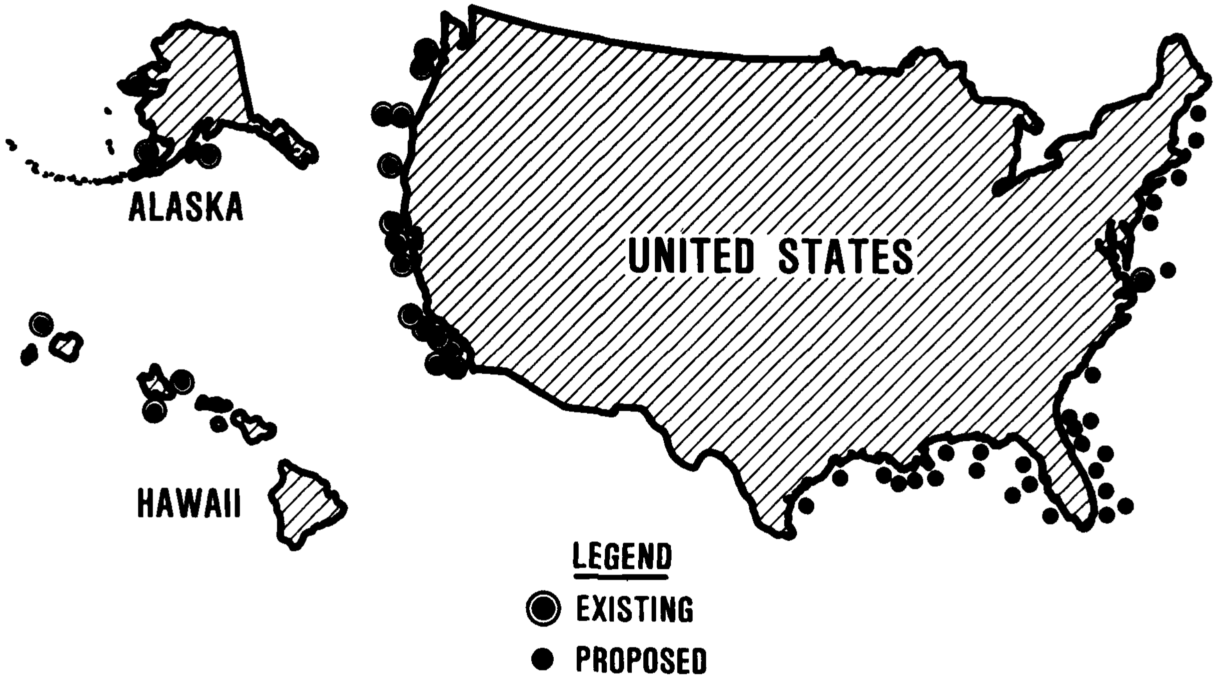

FIGURE 1. WAVE GAGE LOCATIONS

generally representative of long stretches of coastline. These near-shore gages are, on occasion, single pressure gages, or, more often, slope arrays. Data are to be collected from these stations for 5 years to provide the nearshore wave information so necessary to coastal projects and to assist in verification of the numerous wave propagation models. Site selection for slope arrays requires reasonably straight, parallel offshore contours and, like the index stations, consideration of commercial fishing activity. A bottom-mounted sensor can be destroyed by the heavy nets used on large trawlers.

To date, Datawell Waverider buoys have been used in all of the index station installations; the depth of these installations precludes the use of bottom-mounted sensors. The Waverider buoy is a proven instrument which uses a vertically stabilized accelerometer to sense the vertical component of the buoy's motion. Heave data from the buoy are transmitted up to 50 km (31 miles) shore.

Nearshore wave measurements, in depths of up to 15 m (50 ft), are made using a bottom-mounted Kulite semiconductor strain gage pressure transducer. The transducer and its circuitry are housed in a plastic pressure case mated to an underwater cable by a plastic underwater connector. The cable is used both to carry the signal ashore and to supply power to the sensor. Sufficient cable is stored in a service loop to allow the sensor housing to be brought to the surface for servicing, thereby increasing the system's reliability (Seymour, Sessions, and Castel, in press).

An array of four pressure sensors has been developed by Scripps to obtain directional wave data. This array is 6 m (20 ft) square on a side and uses a specially designed armor underwater cable for data and power transmission. This cable has effective abrasion resistance, waterblocking integrity, tensile strength, and resistance to cutting which greatly enhances the system's reliability. Details of the array are described by Seymour and Higgins (1978), and results of laboratory and field tests are discussed by Higgins, Seymour, and Pawka (1981). Seymour, Domurat, and Pirie (1980) describe a test at Santa Cruz, California, where the estimates of gross and net longshore transport calculated from the array compared favorably with the actual sediment volume dredged from the harbor entrance.

Figure 1 and Table 1 show the data collection sites currently being operated under the FWGP and provide information on gage type, percent data return, operational status, and gage ownership in programs other than this one. Operation of the system has been successful. Many of the stations that are not operational were lost or damaged during the severe storms in the early months of 1983 or as a possible result of that year's persistent "El Nino" current. Several arrays sustained cable damage as a result of beach protection or restoration efforts. An increase in buoy losses was experienced that appears attributable to the migration of commercially fished species as a result of "El Nino" and the expansion of the commercial fishing market to include species not previously considered marketable. All but one of the gages should be operational in 1985.

Nearshore gages installed in support of specific projects supplement the data collected under the FWGP. On the Pacific coast, nine project-supported gages are operated through the FWGP network and the data reported by Scripps in the program's reports. The program, therefore, provides an existing system through which project-specific data can be collected, analyzed, and reported, taking advantage of the FWGP computers at Scripps. The system provides the considerable capacity and flexibility needed for coastal data collection and can accommodate any continuously reporting instrument. Tide, surge, current, wind, and wave data are being or have been collected on the system.

TABLE 1

SYSTEM STATUS: DATA COLLECTION REPORT
Month of March 1985

PROGRAM	GAGE LOCATION	GAGE TYPE	CURRENT MONTH	COMMENTS
FWGP	Mission Bay, CA	Buoy	96.8%	
	Mission Bay, CA	Array - Energy	100.0%	
		- Direction	100.0%	
	Scripps, CA	Single Pressure	100.0%	
	Begg Rock, CA	Buoy	93.2%	USN owned
	Santa Cruz Is., CA	Buoy	100.0%	USN owned
	Sunset, CA	Array - Energy	Cable damaged-	
		- Direction	to be replaced	
	Pt. Arguello, CA	Buoy	9.7%	Installed March 1985
	N. Monterey Bay, CA	Buoy	Lost to trawler	To be installed April 1985
	Pacifica, CA	Array - Energy	To be replaced	
		- Direction		
	Humboldt, CA	Buoy	To be replaced	
	Coquille R., OR	Buoy	100.0%	
	Coquille R., OR	Array - Energy	100.0%	
		- Direction	0.0%	Cable damaged by vandals
	Ocean Park, WA	Array - Energy	94.2%	
		- Direction	91.7%	
	Grays Harbor, WA	Buoy	To be replaced	To be installed May 1985
	Makapu'u Pt., HI	Buoy	24.2%	Buoy lost/recovered. To be installed May 1985
	Barking Sands, HI	Buoy	18.6%	USN owned - Interface problems
	Duck, NC	Array - Energy	100.0%	
		- Direction	98.8%	
	Rudee Inlet, VA	Array - Energy	Abandoned	
		- Direction		
MCCP	Imperial Beach, CA	Array - Energy	100.0%	MCCP owned
		- Direction	95.2%	
	Umpqua R., OR	Buoy	100.0%	To be removed May 1985
CCSTWS	Del Mar, CA	Array - Energy	100.0%	CCSTWS owned
		- Direction	100.0%	
	San Clemente, CA	Array - Energy	100.0%	
		- Direction	100.0%	
SPL	Oceanside, CA	Array - Energy	100.0%	SPL owned
		- Direction	100.0%	
City of SF	Farallon Is., CA	Buoy	99.6%	City of SF owned
PG&E	Diablo Canyon, CA	Buoy	99.6%	Adamo-Rupp Installation for PG&E

Related Data Collection Programs

Alaska's coastal data needs are unique. The state has approximately 54,500 km (33,900 miles) of coastline with a climate varying from temperate to arctic. With communities heavily dependent on the sea scattered along the entire coast, Alaska needed a planned approach to its coastal data collection efforts. In 1982, a cooperative agreement was signed between the State of Alaska and the Corps of Engineers to collect coastal wind and wave data. The goals stated in that agreement were, briefly, to collect, analyze, report, and archive coastal data collected by either party; to develop a plan for the collection of coastal data; and to develop instruments, telemetry systems, and analysis procedures suited to the needs and environment of Alaska (Bales, 1984).

Data have been collected at Kodiak, Homer, Akutan, and Whittier. A directional system will be installed at Nome this year. The Alaska Coastal Data Collection Program (ACDCP) is supported by funds from the State Department of Transportation and Public Facilities, the Corps, US Army Engineer District, Alaska (NPA), and the FWGP. Short-term (2 to 3 years) data collection is planned to begin at 17 sites over the next 5 years if state funding continues.

Two types of stations have been developed: one for deep water and the other for nearshore measurements; both include a remote anemometer. For the deepwater sites, Waverider buoys are used. Nome is the only station currently planned for shallow-water operation. There the instrumentation consists of two P-U-V meters to provide directional wave data. Data from both station types are telemetered to a shore station and recorded on magnetic tape. Because data transmission over telephone lines is not reliable in Alaska, a meteor burst transmitter is used to send real-time data to the Corps office in Anchorage. The system uses meteor trails in the upper atmosphere as the medium from which the data are reflected. Meteor burst allows the data to be transmitted over great distances without the use of satellites or telephone lines and provides an inexpensive system check.

NPA publishes data reports periodically as data are processed. To date, three reports have been produced for the stations at Kodiak. The data reports provide the average wind speed and direction, maximum wind speed, and standard deviation of the wind speed and direction for each data collection. Both wind and wave data are reported every 3 hr. Wave data reported include the significant wave height, total energy in the spectrum, and the percent of the energy in frequency bands of 0.02148-Hz width. As more stations become operational, the data reports will be published more frequently.

Another cooperative effort that receives some support from the FWGP involves a contract with the University of Florida to collect, analyze, and report wave data from the Florida coast. The gaging effort is funded by the Corps through the Hurricane Surge Prototype Data Collection Work Unit and the FWGP, by the State of Florida, and by the US Nuclear Regulatory Commission. Eight sites in Florida are operated by the University as the Florida Coastal Data Network (FCDN) using bottom-mounted single pressure transducers. Recently, three P-U-V in situ recording meters were added to provide directional wave data.

The FCDN provides real-time data in support of the hurricane surge work unit. Data reports are produced monthly by the University of Florida for each of the sites operated under the contract. Both tables and plots are used to report the wave data which are collected every 6 hr. Plots of maximum period and significant wave height versus time are included in the reports. The tables provide significant wave height, total energy in the spectra, and the percent energy in various period bands from 4 to 22+ sec for each data collection (Howell, 1980).

Deepwater wave data are also being collected by NOAA. Recently, in support of the Coast of California Storm and Tidal Wave Study, Scripps was able to access the NOAA data for the Pacific and make it available through the CDIP system. Consideration is being given to reporting these data in the monthly and annual reports prepared by Scripps.

Data Collection, Analysis, and Reporting

The data collection system developed by Scripps and used by the FWGP is based on burst rather than continuous sampling. While sampling frequency is field selectable, depending on the data to be collected, it is typically set at 1 Hz for ocean waves measured for the FWGP. Normally each instrument is interrogated once every 6 hr, although certain critical stations are called every 3 hr and the data transmitted to the National Weather Service (NWS).

Data analysis is composed of three phases. The first phase involves the receipt of the raw data from the shore stations and extensive data verification and editing in preparation for the second phase. An analysis phase performs the Fast Fourier Transform (FFT) operations on the edited time series. The final phase operates on the analyzed data to produce the end products, monthly and annual reports. Higgins, Seymour, and Pawka (1981) describe the analytical method for extracting wave directionality from the sea surface slope components measured by the array. The method developed by Longuet-Higgins, Cartwright, and Smith (1963) for use with pitch-and-roll buoy is adapted for use with the array. An estimate of the longshore component of radiation stress S_{xy} can be extracted when surface elevation and components of sea surface slope are known at a point. The components of the slope are determined from differences between a pair of sensors.

The significant data collected under the FWGP are available to users in three forms: direct access via remote terminals, data archives at Scripps and WES, and monthly and annual reports. Data processed since the program's inception are directly available to any user with a computer terminal capable of remote telephone access of the data analysis computer at Scripps. A user-friendly program has been developed to call up tabular and plotted data, including data for single or multiple stations on a single day, a single station on multiple days, or overplotted spectra to allow visualization of a storm's passage. Edited raw data are archived on tape at both Scripps and WES and can be made available to users under certain conditions.

Monthly and annual reports produced by Scripps provide the widest dissemination of wave data collected within the FWGP. After the first month of operation of the origional program in 1975, a report was issued showing spectra and other wave parameters for Imperial Beach, California. Every month since then, analyzed data have been provided through these reports to a large group of public and private users. These data are summarized in an annual report which includes descriptive statistics on wave height and period as well as longshore sediment transport.

Future Effort

A nationwide network of index sites (Figure 1), including the Great Lakes and the Gulf of Alaska, is the goal of the FWGP. That goal will be pursued during the next few years if funding will allow. Expansion of the program to other coasts will require the fiscal support of the Corps. The alternative to good wave data is conservative design, a choice that results in an exponential rise in the cost of coastal projects for the linear increase of design wave height. Current funding levels make it difficult to maintain the existing system; therefore, adequate funding must be provided for the program.

WAVE INFORMATION STUDY (WIS)

Almost all coastal projects have a requirement for wave information, and frequently, it is critical to the determination of the type and cost of solution. Wave information most often must be provided for a 20- to 50-yr design life. Short-term gaging, however accurate, does not meet this need because the climate is variable, as seen by hurricane frequencies on the east coast of Florida (Table 2). When we look at gage records we see there are relatively few years of observations, and often significant parts of the year can be missed because of gage failures (Figure 2). Equally important, unless the gage is in fairly deep water, the gage measurements can be highly site dependent (Figure 3).

Table 2

FREQUENCY OF HURRICANES OFF FLORIDA

PERIOD	LANDFALL	EXIT	PASS BY
1931-1940	7	0	5
1941-1950	4	3	5
1951-1960	0	2	12
1961-1970	5	2	2
1971-1980	0	1	0
TOTALS	16	8	24

The hindcast program uses state-of-the-art models to translate meteorological data and astronomical tide data into coastal wave and water level information (Figure 4). Benefits of this approach include:

(1) Generation of 20 years or more of data.

(2) Availability on a uniform geographical grid.

(3) Availability of directional spectral information.

(4) Absence of lost data.

(5) Application of the system to other areas.

(6) Use of the system to model specific events.

(7) Use of data in an interactive data base.

The trade-off is between lack of extreme wave data and sparsity of spatial coverage in gage data versus imperfections in the wave model. The wave model

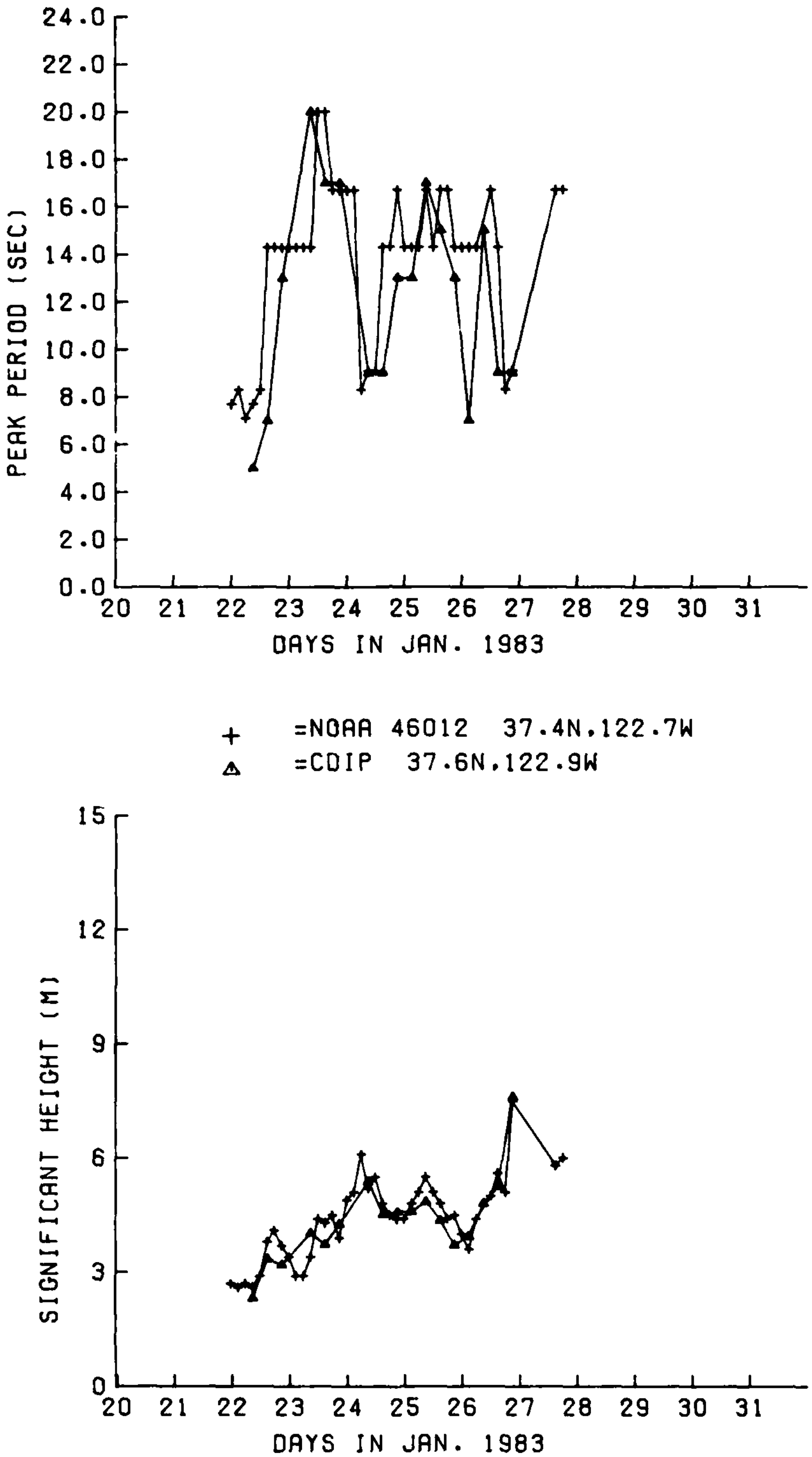

FIGURE 2. GAGE FAILURES DURING JANUARY 1983 CALIFORNIA STORMS

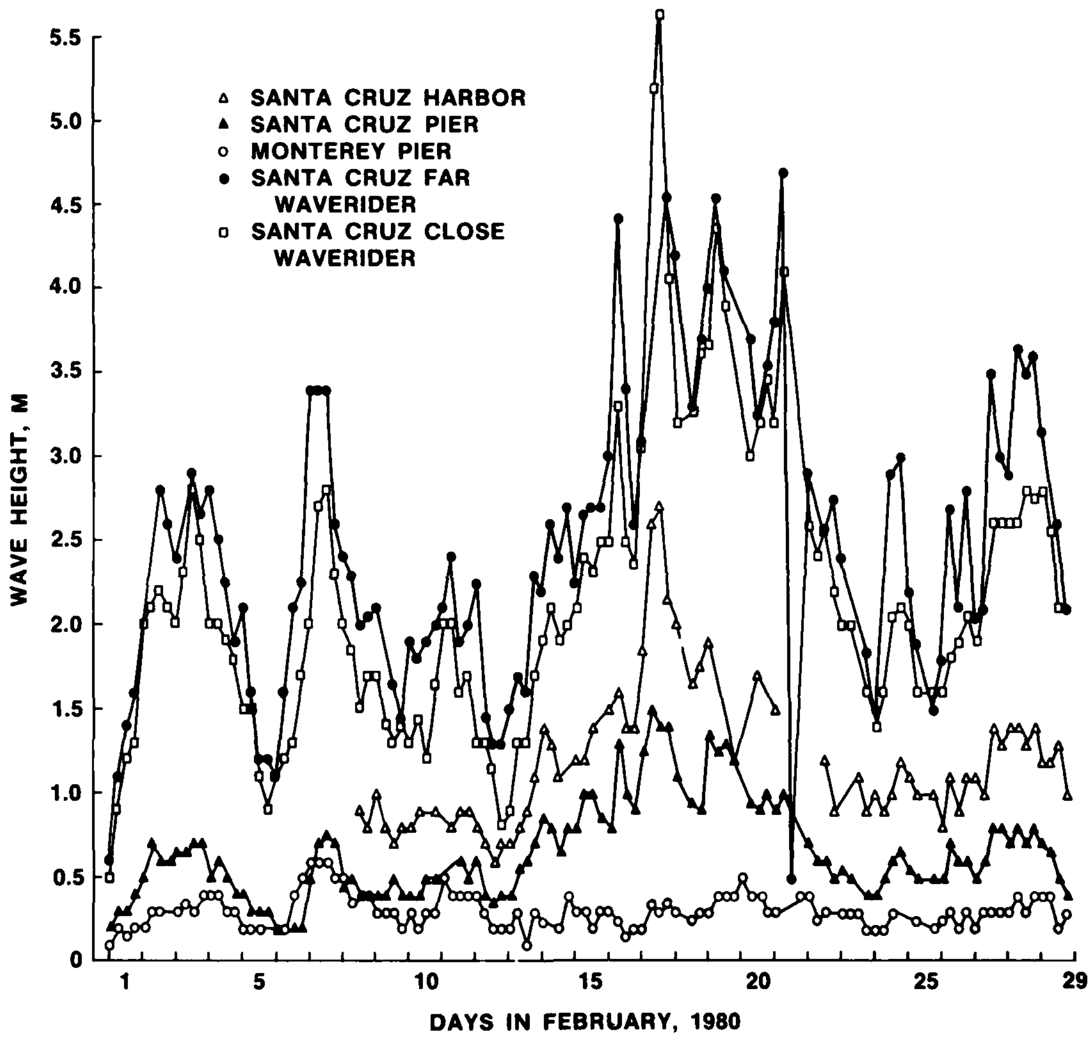

FIGURE 3. VARIATIONS OF WAVE CONDITIONS AROUND MONTEREY BAY

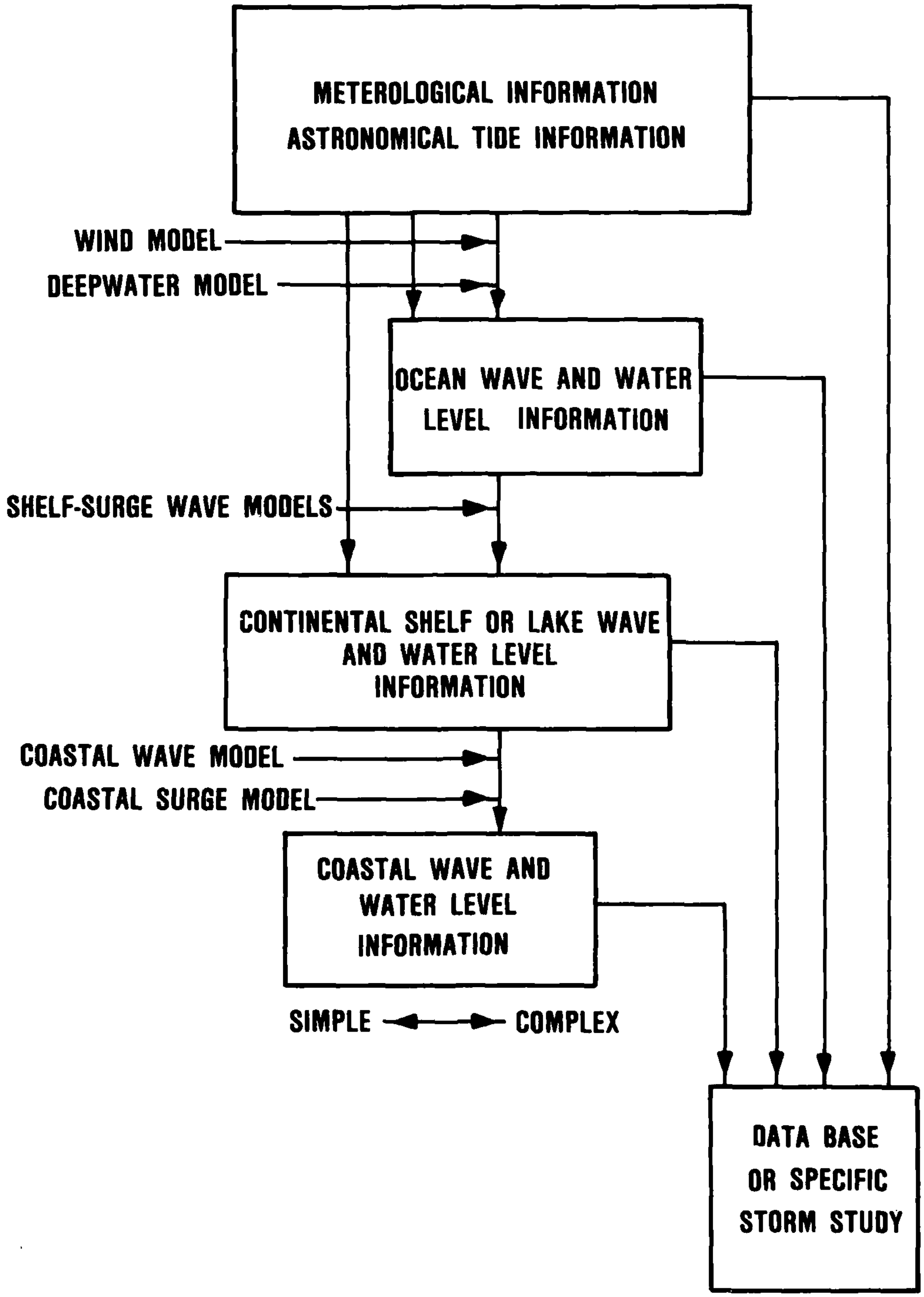

FIGURE 4. MODEL SYSTEM FOR WAVE INFORMATION STUDY

AD-A159 991 PROCEEDINGS OF THE MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD (43R..(U) COASTAL ENGINEERING RESEARCH CENTER VICKSBURG MS R W WHALIN AUG 85 4/6

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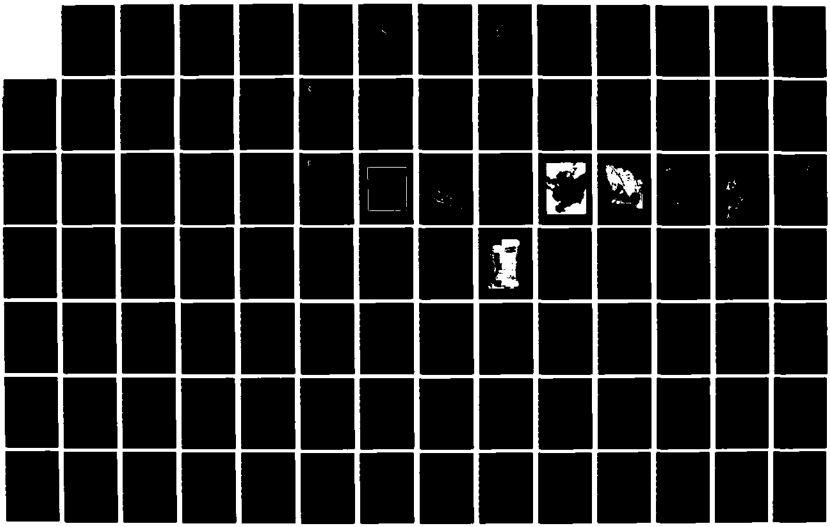

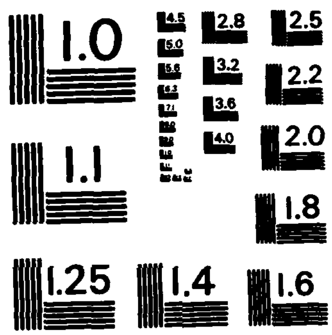

MICROCOPY RESOLUTION TEST CHART
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has been extensively compared to observations (Figures 5 and 6) and performs as a quality, state-of-the-art model.

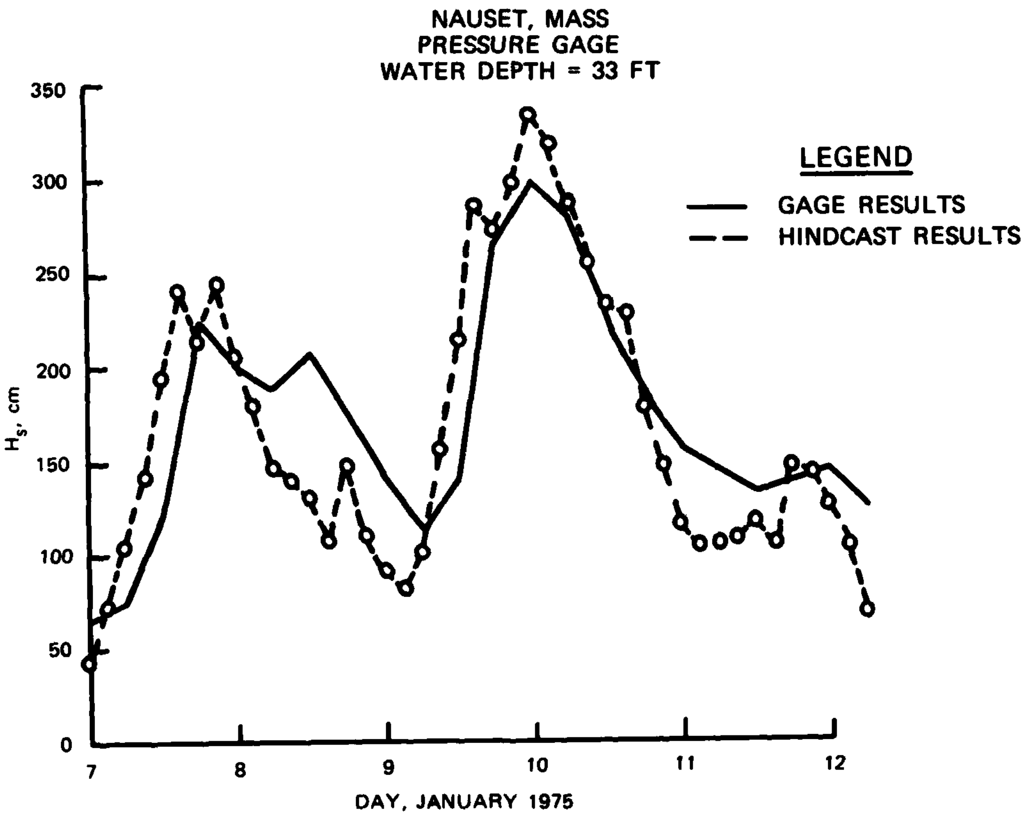


FIGURE 5. EXAMPLE OF MODEL VERIFICATION ON ATLANTIC COAST

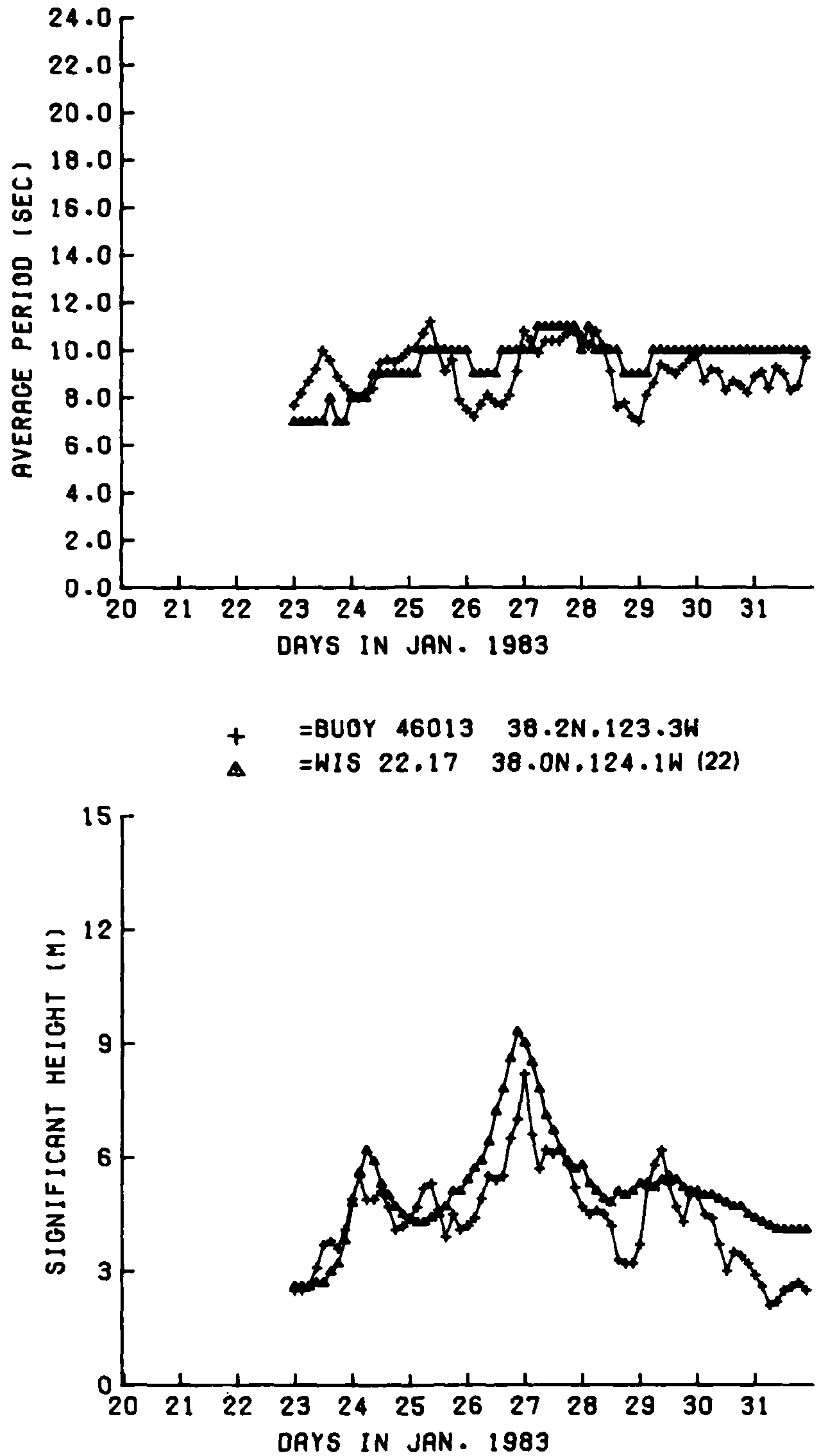


FIGURE 6. EXAMPLES OF MODEL VERIFICATION ON PACIFIC COAST

Past Efforts

In prior fiscal years the model system was developed and refined and hindcasts made in specific areas (Figure 7). The I, II, and III represent different levels of density of information at 120-, 30-, and 10-nautical mile grids, respectively. Excepting hurricanes, the Atlantic and the large-scale Pacific have been finished for a 20-year period. Major storms in the Atlantic have been analyzed back to 1900 to give a 75-year basis for extreme wave estimates. This fiscal year the plan is to finish the Pacific with the exception of hurricanes, add hurricanes to the Atlantic, and finish the first level in the Gulf of Mexico (Figure 8). Additional work necessary in future years includes the following:

(1) Completion of Gulf of Mexico, including hurricanes.

(2) Addition of Pacific hurricanes.

(3) Addition of Great Lakes.

(4) Completion of water level data bases.

(5) Addition of more interactive programs to the Sea State Engineering and Analysis System (SEAS).

It should be noted that at each of the locations where data are saved (Figures 9-13) there will be over 58,000 sets of wave parameters available on an on-line data base for District office use. This data base, which has been designated as SEAS, is indeed the only way we can economically make the information available because there is so much of it. CERC plans to add or interface other programs and models to SEAS to provide a basis for an integrated design system for applications that require wave and water level information. The purpose of SEAS is to provide the following:

(1) Rapid access data (height, period, direction for sea and swell)
- (a) Time series
- (b) Probability tables
- (c) Water levels

(2) Slower access data
- (a) Frequency spectra
- (b) Directional spectra

(3) Application programs
- (a) Statistics
- (b) Display
- (c) Engineering

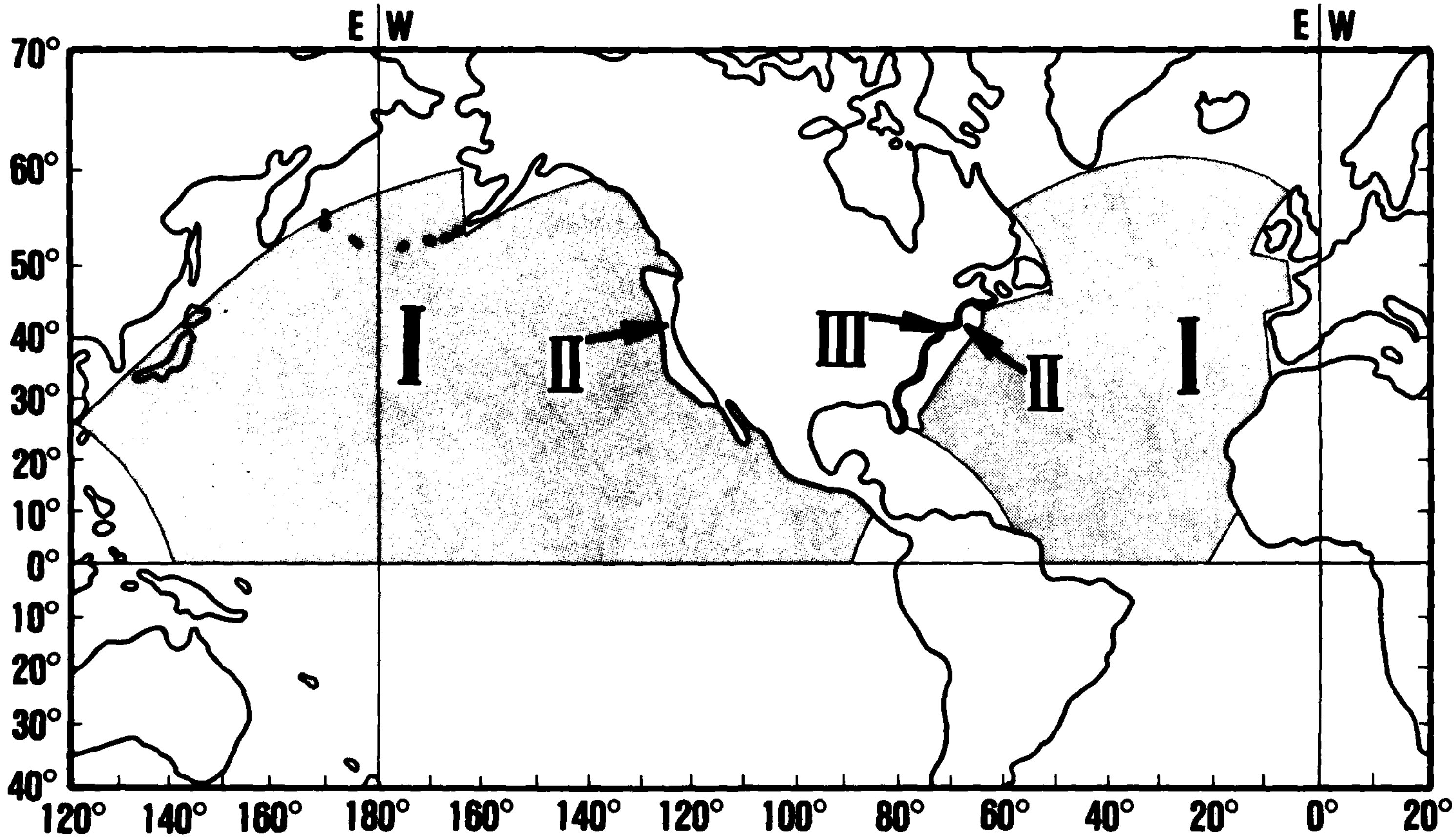


FIGURE 7. HINDCAST EFFORTS IN PREVIOUS YEARS

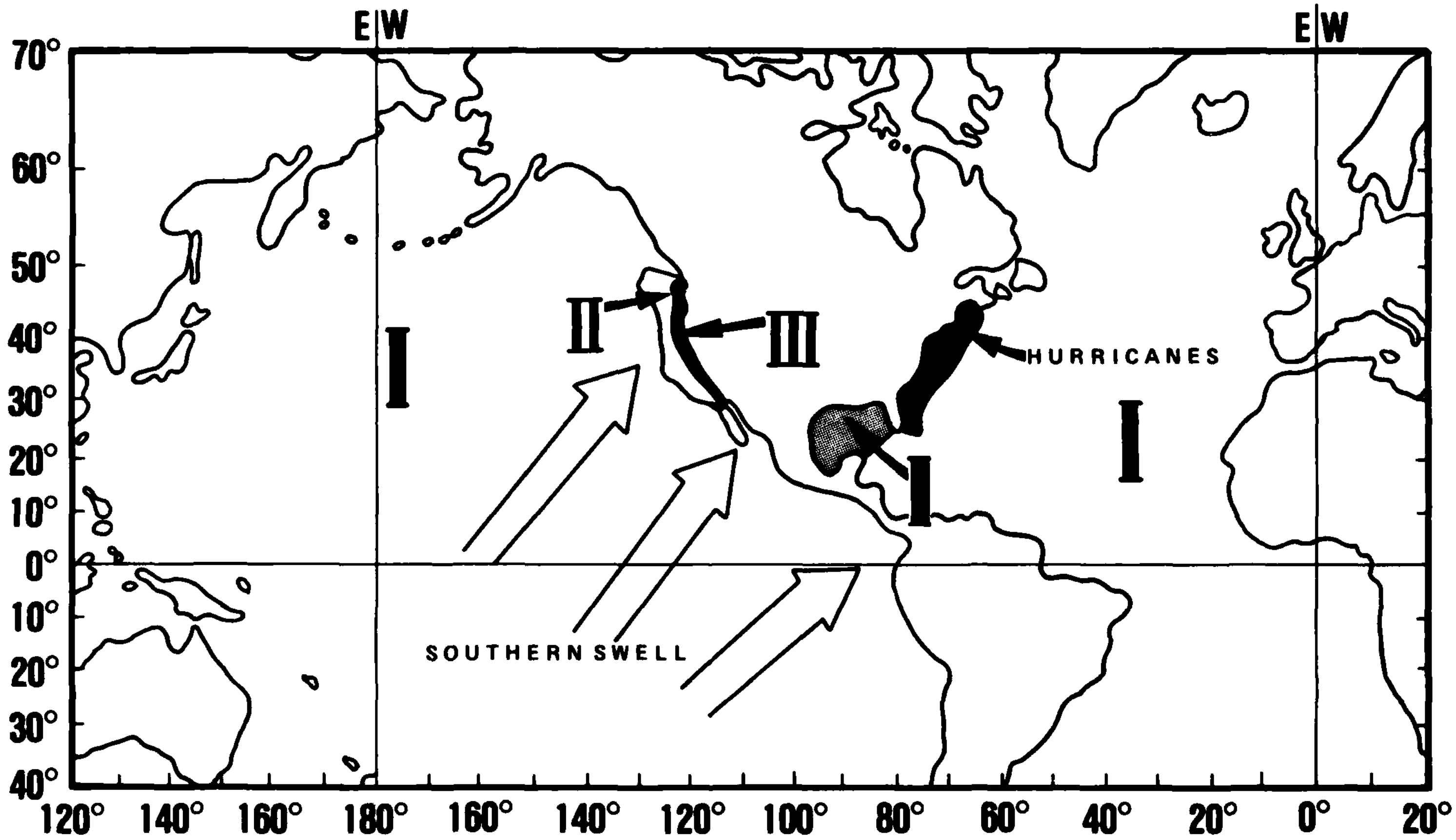


FIGURE 8. HINDCAST EFFORTS THIS FISCAL YEAR

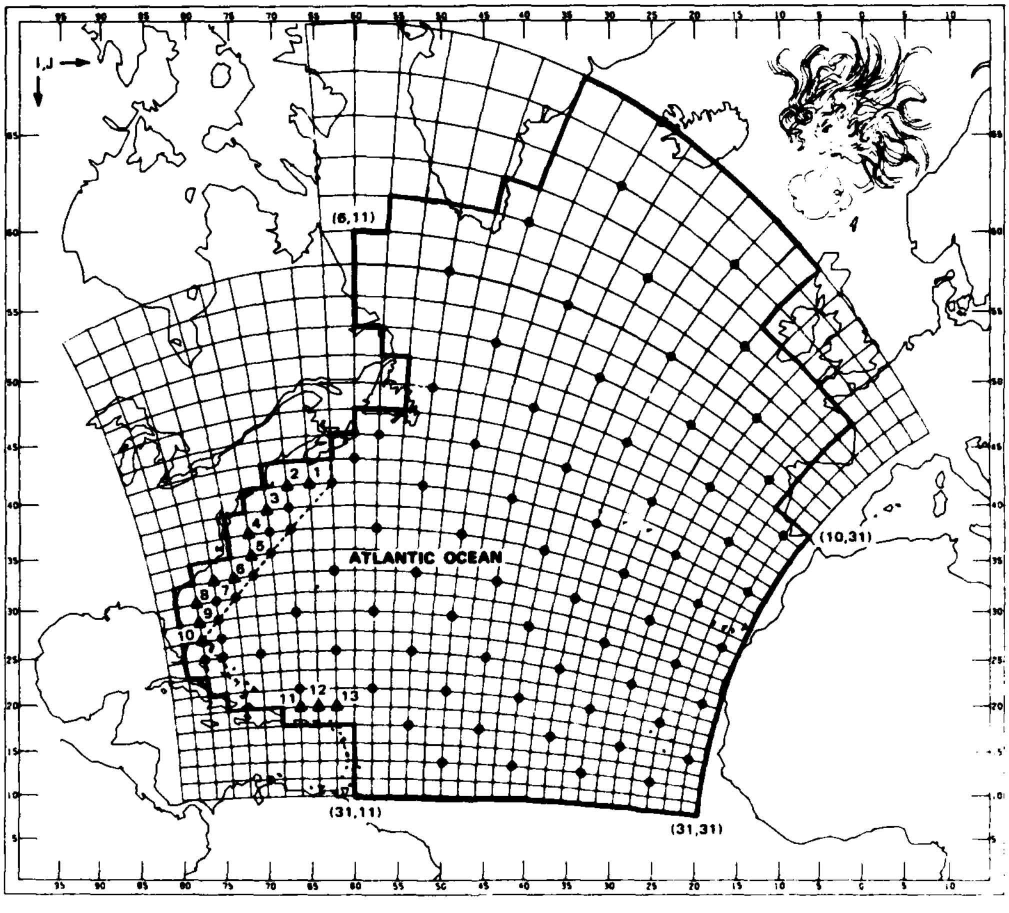


FIGURE 9. ATLANTIC PHASE I STATIONS

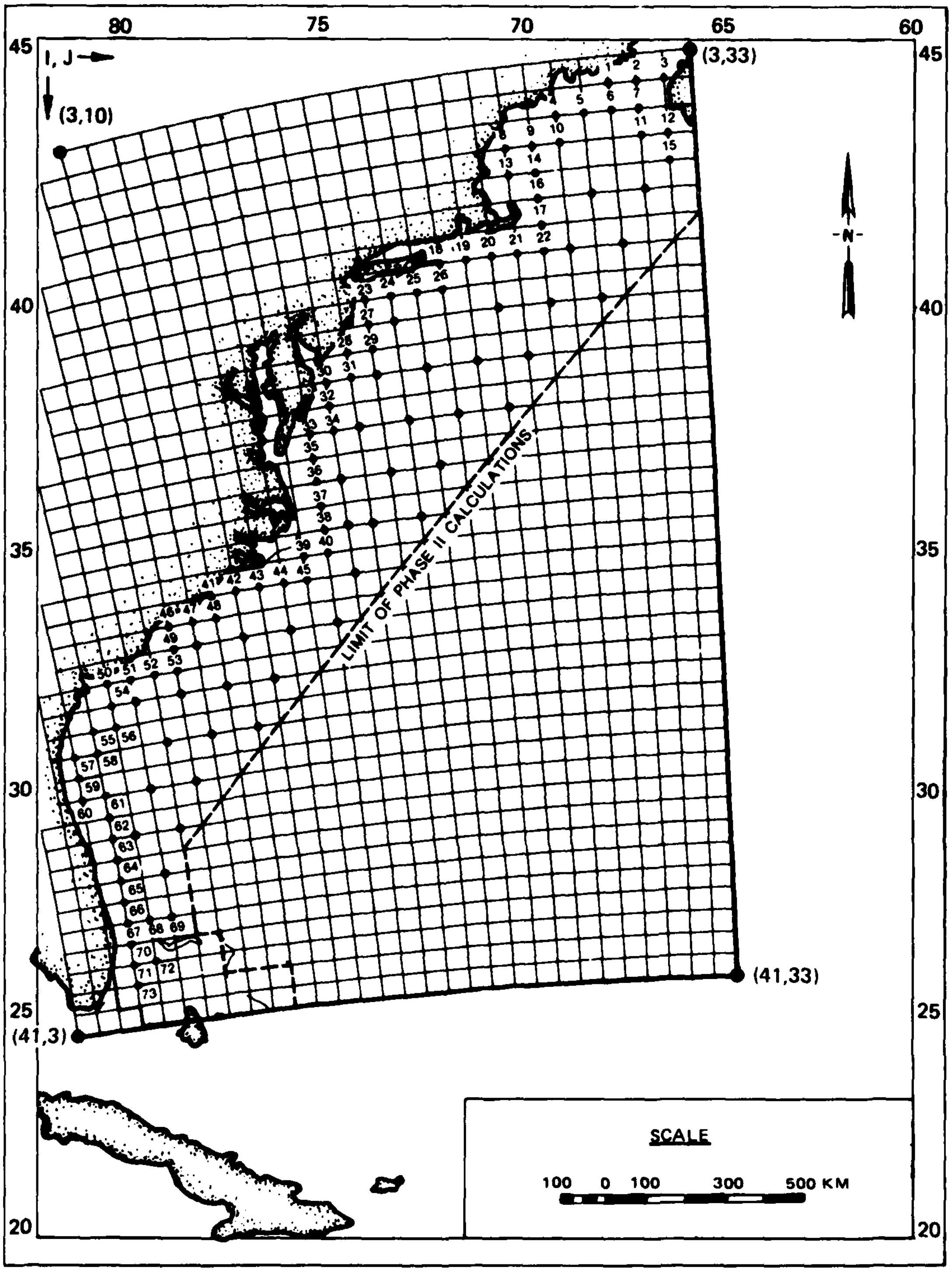


FIGURE 10. ATLANTIC PHASE II STATIONS

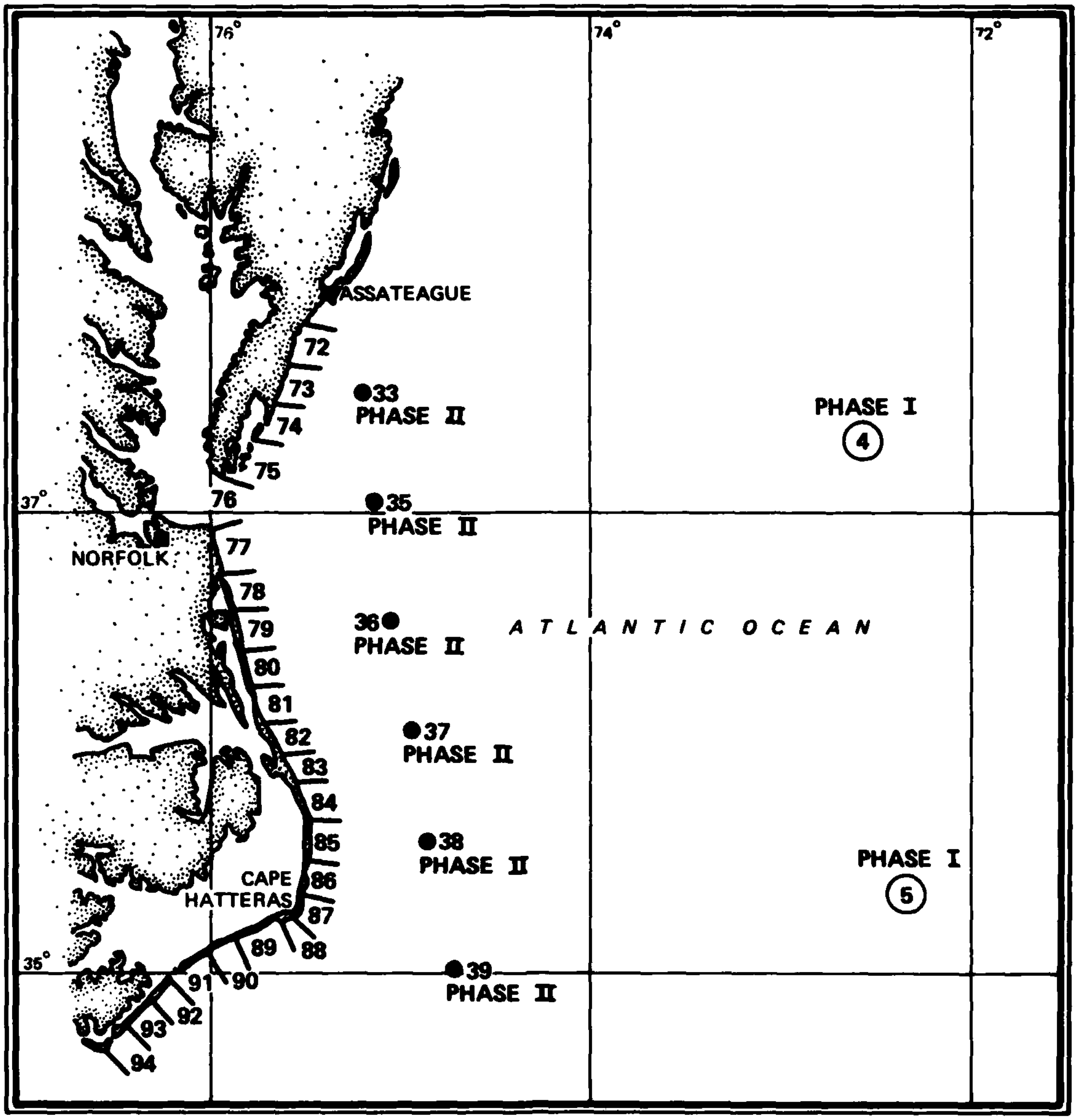
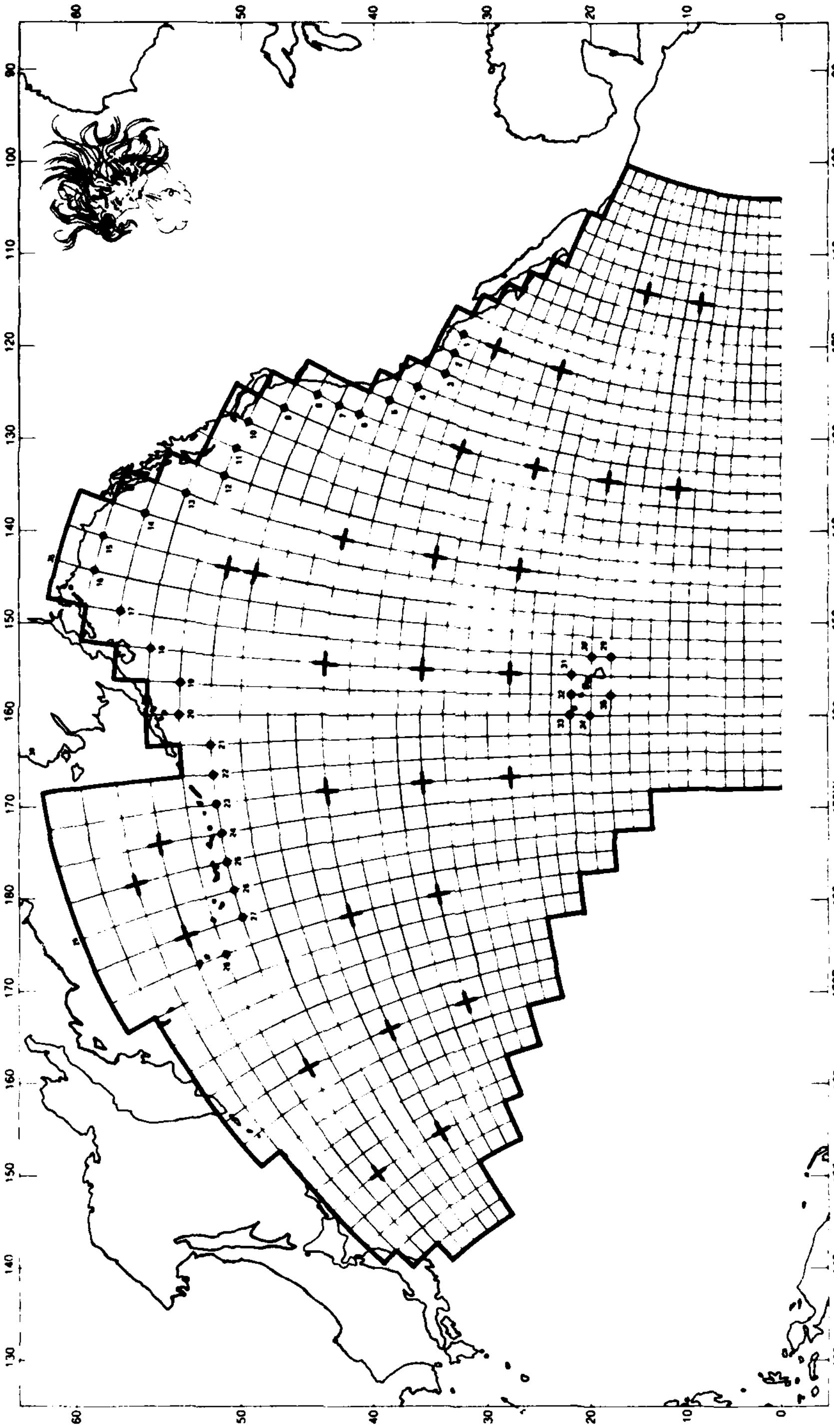


FIGURE 11. EXAMPLE OF ATLANTIC PHASE II STATIONS



MERCATOR PROJECTION OF PACIFIC OCEAN

FIGURE 12. PACIFIC PHASE I STATIONS

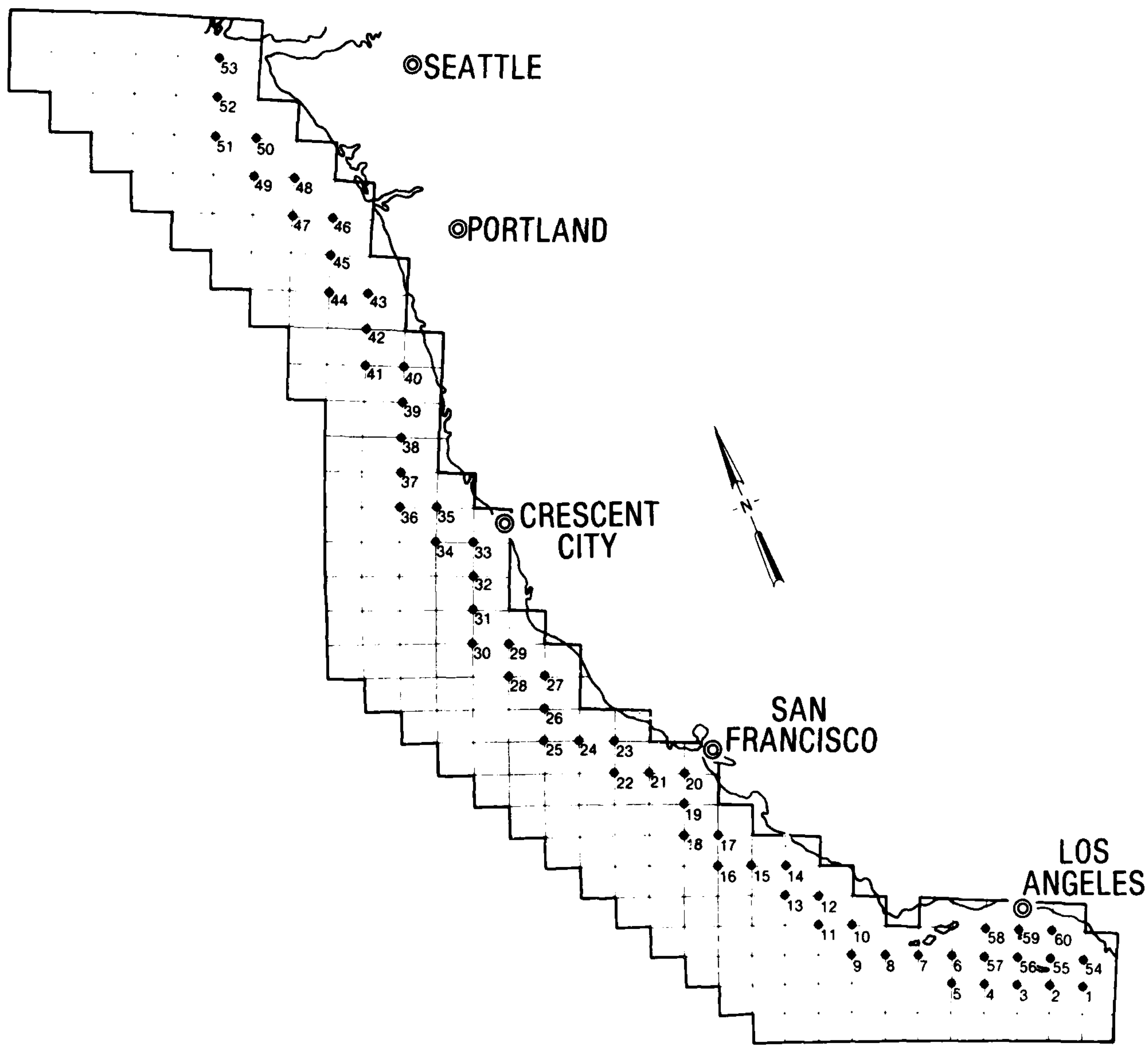


FIGURE 13. PHASE II PACIFIC GRID

Future Efforts

To review, a state-of-the-art system for translating meteorological and tide data into coastal wave and water level information and disseminating the information through an interactive data base is in place. The system can be run in the long-term hindcast mode, or it can be used to study specific events. In principle, it can be applied to other areas of the world if the Army needs it.

Since the hindcast study began, the following events have occurred:

(1) The computers used have increased by a factor of about 30 in speed, and another factor of 10 can be expected in the next few years.

(2) Wave measurement systems have become more reliable and now can provide directional estimates.

Both of these provide unique opportunities for improvement of wave climate estimates. Although wave gages have improved and satellites are expected to become operational wave data collection platforms, it may be another 10 years before reasonably spaced spatial and temporal coverage are available and over a 5-year basis of information is gathered.

The increased speed of computers gives us the opportunity to increase our basic data basis to 30 or even 40 years by the time gaging begins to provide climate information on a national basis at a lower cost compared to establishing the first hindcasts. This increased time base is particularly important to understand the effects of year-to-year variability in waves and water level climates. If significant advances are made in wave modeling, it will be possible to regenerate the climatology cost effectively because of the existing winds developed and the increase in speed of computers.

Even as more observations become available, it is unlikely that they will be available on the 10-mile spacing that the model can produce, even into the next century. One opportunity, however, is to incorporate the gage and satellite data directly into the wave model calculations, not simply to use them as verification (Figure 14). Then, the model system results can provide finer spatial scale information based upon a combination of both atmospheric and gage data. Models currently being tested at CERC will be able to refine coastal calculations down to a grid size of about 100 m or less for detailed site-specific studies.

Thus it can be seen that the future of WIS is to allow future improvement to the basic wave climate to a 30- to 40-year basis and to provide a

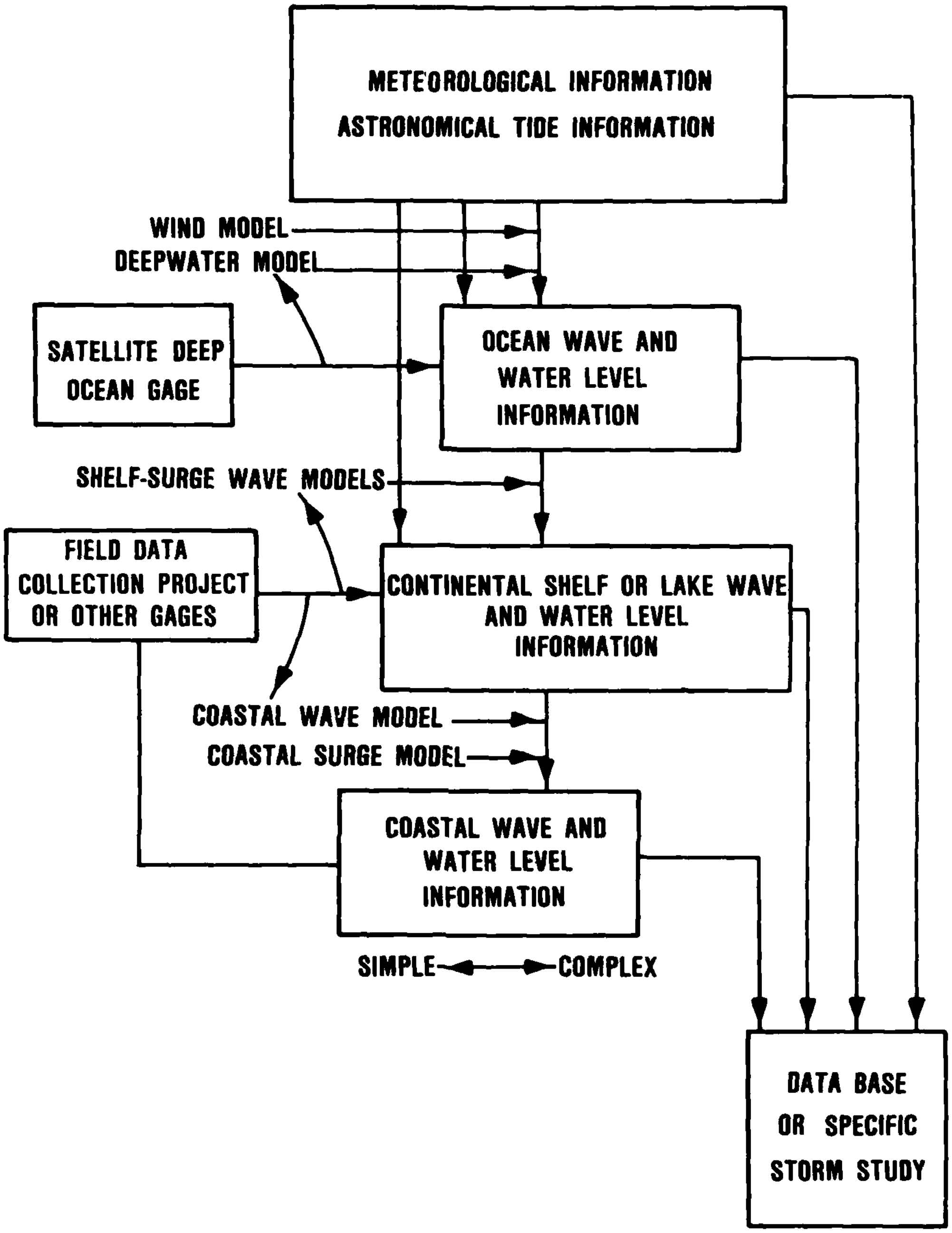


FIGURE 14. PROPOSED INTERFACE OF GAGE AND SATELLITE DATA INTO MODEL SYSTEM

framework for interpreting the field gage or satellite information into site-specific wave statistics needed for design. Further, the model system allows the investigation of "what if" or hypothetical events. CERC sees WIS as providing the basis for the critical development of interactive design systems through interfacing advances in other coastal technological areas to this very basic data base. This systematic approach provides a rational framework for turning the numerous pieces of wave and water level data into information that can be used in design

LITTORAL ENVIRONMENT OBSERVATION PROGRAM

The Littoral Environment Observation (LEO) Program is a visual data collection program that has been ongoing under CERC's direction since 1968. The objective of the LEO Program is to establish an economical reservoir of repetitive and systematic observations of both the forces and response elements in the coastal zone at sites where no data exist or where funds are not available for sophisticated instrumentation. The data collected include wave height, period, and direction, width of surf zone, wind speed and direction, longshore current and direction, and beach slope. Over its 15-year existence, data at over 200 sites have been collected.

A data base and a user-friendly retrieval system have been developed and are presently undergoing evaluation before they are made available to engineers at Corps Districts. The data base and retrieval system is operational on Control Data Corporation's (CDC's) Cyber 170 Corps dedicated computer in Rockville, Maryland. The retrieval package consists of various statistical reports that summarize the data at a particular site. A user's manual is being developed and will be available to Corps engineers in fiscal year 1986 (FY 86).

Plans are under way to conduct a study in conjunction with the "DUCK 86" experiment to improve the methodology for visual coastal field data collection. Plans are also under way to develop a capability for downloading the LEO data from the main data base to a personal computer (PC) for local analysis.

In summary, the LEO Program has provided an economical data base of coastal information at sites where no other data exist.

THE COASTAL ENGINEERING INFORMATION MANAGEMENT SYSTEM INDEX SUBSYSTEM (CEIMS/IS)

Voluminous amounts of data and written reports exist for the United States and its territories. A need to make these valuable sources of information readily accessible to Corps personnel presently exists and will continue to increase in the future. A Corps-wide interactive CEIMS/IS has been developed to catalog the existence, location, and characteristics of coastal data and written documents containing information about specific coastal reaches. In order to adequately address all sources of coastal information, the CEIMS/IS is divided onto two classes: coastal studies and technical journals. The coastal studies class references all data collection efforts, studies, and raw data sets; whereas the technical journals class provides a catalog for all written documents (published or unpublished). This user-friendly IS, the first module of two to be implemented for CEIMS, points to the existence and location of coastal information for an area or data type. In addition, it provides a pathway to the second module, the Data Access Subsystem (DAS), which will be implemented in stages beginning in FY 86. The DAS module of CEIMS will allow access to a variety of coastal studies digital data residing on the Cybernet System and other computer storage facilities.

CEIMS/IS has been installed on CDC's Cybernet Network System to provide availability to all Corps personnel. The host system exists on a Cyber 865 located in Rockville, Maryland, and uses BASIS, a relational data base software product. This software provides the backbone of the CEIMS/IS and is capable of running on a variety of machines. BASIS's machine independent capability will add to the longevity of CEIMS/IS if the need arises to move the system to another network in the future. This host system may be accessed for data entry or retrieval using a dumb terminal, intelligent terminal, or PC.

A PC-level capability has been augmented also into the system. This micro-software package provides an alternative to interactive data entry and retrieval on the main frame host system which results in a substantial user cost savings. Data may be transferred to and from the main frame host system via the PC. The PC capability allows a user to compile, retrieve, and manipulate data records at any location with a capability to connect to the host system when a communication line is available. The user can enter from the PC into the main frame host system through the communications software included in the PC package and query the main data set from the PC. Data records may be requested from the main frame system and downloaded to the PC-level work station where additional querying and sorting may be performed. Users may store on their PC's downloaded information retrieved from the main frame host system for manipulation at a later date.

The design of CEIMS/IS allows users to feed information directly into the system. This will allow a much more comprehensive and rapidly filled data base to be compiled. To ensure quality control, all data entered into the CEIMS/IS from either the PC or the main frame host-system level are verified by the system's administrator before final entry into the main data-base file.

CEIMS/IS has been well received to date. Requests for information concerning how to access the data base have been filtering into CERC. A cooperative effort is presently under way between CERC and the Jacksonville District to enter information for the Coast of Florida Erosion and Storm Effects Study. Inclusion of data and active participation from Florida state agencies and academic institutions is scheduled to begin this fiscal year. The Los Angeles District has also contributed data from the Coast of California Storm and Tidal Wave Study and is scheduled for user training in May of this year.

Since the CEIMS/IS effort was begun in FY 84, design, development and implementation of the Corps-wide interactive CEIMS/IS have been completed. The IS, the first of two CEIMS modules to be developed, points to the existence and/or location of coastal information for an area of interest or a specific data type. CEIMS/IS provides the Corps with a time-saving and efficient tool for cataloging and accessing sources of coastal information pertinent to their project interests.

FUTURE EFFORTS

In addition to the elements of the CFDCP discussed, it has been proposed that the program be expanded to include shore and beach information, measurement and documentation of episodic events, and increased support for the ACDCP.

Shore and Beach Information

The shore and beach information element of the program will incorporate LEO and renew the shoreline change map effort and profiles program. The objective is to quantify the long-term, seasonal, and storm-induced beach, dune, and nearshore profile changes. These data are essential to the determination of erosion and accretion rates. Preparation of shoreline change maps from historical information and the identification, interpretation, archiving, and reduction of profile data at District offices will provide the needed data.

Measurement and Documentation of Episodic Events

An existing research effort, The Hurricane Surge Prototype Data Collection work unit, will become a part of the CFDCP and be expanded to include a wider variety of episodic events. The objective of this effort is to provide the quantity and quality of timely data required to more accurately document the characteristics and effects of events such as severe storms and tsunamis. Data collected will provide the information needed for verifying the numerous numerical models used to predict surges caused by severe events. The methodology developed under the work unit will benefit the expanded effort under CFDCP.

SUMMARY

The objective of the CFDCP is to systematically acquire and assemble the geophysical information required for cost-effective planning, design, construction, and maintenance of coastal projects, to archive the data in a computer-based information system, and to routinely and rapidly disseminate information to Corps planners, engineers, scientists, and managers. Work is under way to archive that objective, but much is left to be done.

ACKNOWLEDGEMENTS

The investigations described in this paper were undertaken by WES as a part of the CFDCP, Civil Works Program of the Corps. Mr. John H. Lockhart, Jr., was technical monitor for this program which was managed by Mr. John Mikel, Operations and Readiness Division, Office, Chief of Engineers. The authors wish to acknowledge the Chief of Engineers, US Army Corps of Engineers, for permission to publish this paper.

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MONITORING COMPLETED COASTAL PROJECTS

CERB Proceedings

Mr. J. Michael Hemsley
Research Hydraulic Engineer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

Since the Monitoring Completed Coastal Projects Program was begun in fiscal year 1981 (FY 81), data on project performance have been gathered at 10 Corps of Engineers (Corps) coastal projects. Monitoring has been completed at four of those projects, and final reports are in preparation. Recently, five additional projects were selected for monitoring beginning in FY 86. While the program is only in its fifth year, results of the monitoring efforts have already benefited Corps offices by providing information to better develop operation and maintenance programs for the structures studies by developing new inspection techniques and by testing the criteria used in coastal design.

INTRODUCTION

In the United States, construction of public works to develop water resources is the responsibility of the Corps. These works include projects to improve ocean and coastal navigation, to protect and restore eroding shores, and to protect coastal areas against storm-induced flooding. To date the Corps has been involved in hundreds of harbor and navigation projects, beach and shore protection projects, and coastal flood protection projects on every coast. Long a leader in coastal engineering research, the laboratory accomplishments of the Coastal Engineering Research Center (CERC), part of the Corps' Waterways Experiment Station (WES), are well known to the coastal engineering community worldwide. The Corps, like other members of the coastal engineering community, is keenly aware of the complementary relationship between laboratory research and prototype monitoring. Neither is complete without the other.

During the last three or four decades, remarkable and rapid progress has marked the laboratory studies of the physical processes dominating the world's coastal zones. A great deal is now known about those processes. Believing that the time had come for intensive, parallel field studies of the interaction of projects with those processes, the Corps established the Monitoring Completed Coastal Projects (MCCP) Program, a national program to assure comprehensive, systematic monitoring of coastal projects. This is the only program of this nature in the United States.

OBJECTIVES

Simply stated, the aim of the program is the advancement of coastal engineering technology. It is designed to determine how well projects are accomplishing their purposes and resisting the attacks of the physical environment. These determinations, combined with the concepts and understanding already available, will lead to upgrading the credibility of predictions of cost effectiveness of engineering solutions to coastal problems; to strengthening and improving design criteria and methodology; to improving construction practices; and to improving operation and maintenance techniques. Additionally, the monitoring program will identify concerns that laboratories should address more intently. Stated in another way, the objective is the advancement of the engineering science derived from insights into the physics that laboratory studies have developed.

HISTORY

To develop the direction for the MCCP Program, the Corps established an ad hoc committee of coastal engineers and scientists. The committee formulated the program's objectives, developed its operational philosophy, recommended funding levels, and established criteria and procedures for project selection. A significant result of their efforts was a prioritized listing of problem areas to be addressed. As shown below, this is essentially a listing of the program's areas of interest. The initial list compiled had only the first 20 items. As the program has grown, so has the list; the final items were recently added.

(1) Shoreline and nearshore current response to coastal structures.
(2) Wave transmission by overtopping.
(3) Prediction of the controlling cross section at inlet navigation channels.
(4) Wave attenuation by breakwaters (submerged and floating).
(5) Bypassing at jettied and unjettied inlets.
(6) Wave refraction and steepening by currents.

(7) Beach-fill project monitoring.

(8) Stability of rubble structures - investigations to determine causes of failure.

(9) Comparison of preconstruction and postconstruction sediment budgets.

(10) Wave and current effects on navigation.

(11) Dynamics of floating structures.

(12) Wave reflection.

(13) Effects of construction techniques on scour and deposition near coastal structures.

(14) Diffraction around prototype structures.

(15) Wave runup on structures

(16) Onshore/offshore sediment movement near coastal structures.

(17) Harbor oscillations.

(18) Wave transmission through structures.

(19) Material life cycle.

(20) Ice effects on structures and beaches.

(21) Model study verification.

(22) Wave translation.

(23) Construction methods.

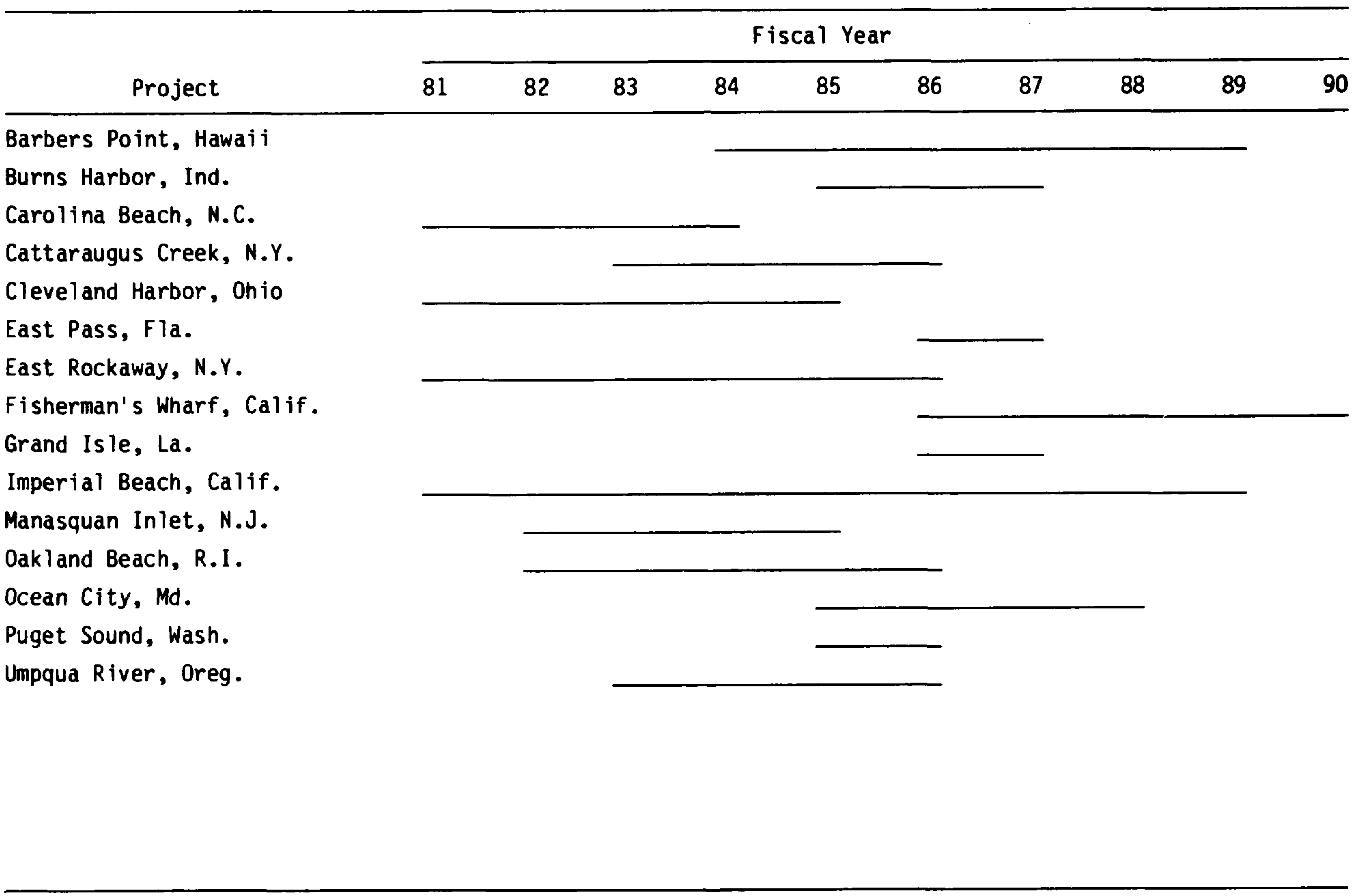
The selection process envisioned by the committee members has worked well since the first projects were nominated in 1981. Periodically, the Corps' coastal offices are invited to nominate projects for monitoring under the program. Nominations are reviewed and prioritized by a selection committee comprised of representatives from the Office of the Chief of Engineers (OCE), CERC, and several coastal Division offices. Final selection is based on the prioritized list of projects and the available funding. Projects have been selected for the program each fiscal year from 1981 to 1985.

While guidance is provided by OCE, management of the program rests with CERC. Operation of the program, though, is a cooperative effort between CERC and the individual Corps District offices. Development of the monitoring plan and conduct of data collection depend on the combined resources of CERC and the Districts.

PROJECTS

Table 1 lists the projects being monitored or selected for monitoring

TABLE 1
COASTAL ENGINEERING RESEARCH CENTER
MONITORING COMPLETED COASTAL PROJECTS



within the MCCP Program. The projects are varied both by geographic region and by purpose. One of the first projects selected for the program was the Carolina Beach, North Carolina, beach erosion control-hurricane protection project. Approximately 2,632,000 cu yd of fill were required to complete the project in 1965. Since then, a groin, rubble-mound seawall, and additional fill have been required to maintain the project. In 1981, a 400,000-cu-yd sediment trap was dredged in the inlet as a source of nourishment sand. The monitoring effort is designed to determine the effectiveness of the sediment trap as a primary source of nourishment for Carolina Beach and to assess the impact of the trap on the inlet's ebb tidal channel and delta.

The easternmost 4,400 ft of the Cleveland, Ohio, breakwater were rehabilitated with 2-ton, unreinforced dolosse to ensure the integrity of the 90-year old structure. Work was completed in 1980, with the monitoring effort beginning the next year. Quantification of armor unit breakage and determination of the level of breakage that would compromise the integrity of the structure are the primary objectives of the monitoring effort. Additional objectives are the investigation of wave transmission by overtopping, identification of ice effects on the structure, and evaluation of side-scan-sonar (SSS) as an inspection tool.

In 1971, 7.1 million cu yd of fill were used to nourish the 6.2-mile-long East Rockaway to Rockaway Inlet Erosion Control Project on Long Island in New York City. Subsequently, isolated reaches of erosion were repaired in 1978, 1979, 1980, 1982, and 1984. During the summer of 1982, a 380-ft-long terminal groin was built at the western limit of the project. Monitoring program objectives include evaluation of the structural, functional, and economic performance of the project; determination of the effects of groin construction on scour and deposition; and comparison of pre- and post-beach-fill sediment budgets.

At Imperial Beach, California, a submerged, offshore breakwater with alternating high (0.0 ft mean lower low water (MLLW)) and low (-3.0 ft MLLW) crest sections is proposed. Connected to shore by groins at each end, the project is designed to protect the developed shoreline. The project, which has suffered several delays, is scheduled for construction during the summer of 1985. Monitoring the breakwater will help evaluate the design criteria and model studies used in developing this unique coastal structure, document the performance of the structure and its impact on the shoreline, and evaluate innovative construction methods.

During the program's second year, projects at Manasquan Inlet, New Jersey, and Oakland Beach, Rhode Island, were added. Jetties at Manasquan Inlet, originally constructed between 1930 and 1931, were rehabilitated with 16-ton reinforced concrete dolosse. Rehabilitation of the south jetty occurred between 1979 and 1980 and of the north jetty between 1981 and 1982. Monitoring this project will evaluate the armor units' performance in stabilizing the jetties, determine the structures' effects on local longshore transport, and test the ability of the jetties to maintain a stable inlet cross section.

To combat erosion at Oakland Beach in Warwick, Rhode Island, a rock revetment, high terminal groins, and a low profile groin were constructed to retain the fill placed on the beach. Construction was completed in the summer of 1981. The monitoring program objectives include documenting the performance of the individual structures and the project as a whole and testing a numerical model that relates wave climate to winds in a depth and fetch limited situation.

Cattaraugus Creek, New York, and Umpqua River, Oregon, navigation improvement projects were selected for the MCCP Program in FY 83. Construction of Cattaraugus Creek Harbor, consisting of two shore-connected, rubble-mound breakwaters and nearly one mile of channel improvements, was completed in January 1983. The project objectives were to maintain the navigation channel and eliminate the bar at the stream mouth, thus minimizing spring ice jams and the resulting floods. Monitoring objectives are to evaluate the response of the shoreline and navigation channel to the breakwaters, evaluate the stability of the structures, compare preconstruction and postconstruction sediment budgets, and determine the effects of ice on the structures and vice versa.

In 1977, improvements to the north jetty at the Umpqua River entrance were undertaken to reduce the amount of sediment passing through the structure. An extension of a training jetty to connect with the head of the south jetty was completed in 1980 to further stabilize the channel and reduce reported cross currents. By evaluating the response of the river mouth, navigation channel, and beach to the jetty improvements, the monitoring effort will compare the prototype conditions to those predicted by previous studies. Secondary objectives include evaluating wave transformation into the river entrance and correlating nearshore wave conditions with structural damage.

Only one project was added to the program during the next fiscal year, the harbor development at Barbers Point on Oahu in Hawaii. A 92-acre deep draft harbor has been recently excavated on the southwest shore of Oahu. Nearly 4,700 lin ft of rubble wave absorber will be constructed along the interior channel and basin slopes to reduce wave heights in the basin. Monitoring will compare the predicted and prototype effectiveness of the wave absorber, evaluate wave transformation into the basin, and determine surge levels in the harbor.

While six projects were selected in FY 85, only one will be monitored this year. Three floating breakwaters in Puget Sound, Washington, have been constructed by the Corps since 1982. Two concrete structures are located at Olympia and Friday Harbor. The third, constructed of scrap tires, is located at a private marina at Johnson Point, north of Olympia. Two other structures, of four under consideration, may also be monitored. These structures vary in design, site condition, and wave exposure. They will be monitored to evaluate operational performance, analyze causes of damage, and document successes and problems associated with normal use. The remaining projects, to be funded for monitoring next year, include breakwaters at Burns Harbor, Indiana, and at Fisherman's Wharf in San Francisco, California; jetties at East Pass, Florida, and Ocean City, Maryland; and a beach erosion/hurricane protection project at Grand Isle, Louisiana.

Data being collected are nearly as varied as the projects. Table 2 shows the data for each of the ongoing projects. These data are being collected in support of the monitoring objectives for those projects.

RESULTS

While the MCCP Program is still young, it has already begun producing results. Four of the monitoring efforts were recently completed: Carolina Beach, Cleveland Harbor, Manasquan Inlet, and Umpqua River. Final reports are being prepared for each effort and will discuss the results achieved in detail. Preliminary results from these and other MCCP efforts are already being used by the District offices involved in the monitoring. As the data are analyzed and published, they will become available for use by the coastal engineering community for the planning, design, construction, operation, and maintenance of coastal projects.

Data on dolosse movement and breakage from Cleveland Harbor, in particular, and Manasquan Inlet have been used to help modify the maintenance

TABLE 2
MONITORING COMPLETED COASTAL PROJECTS DATA

Project	Aerial Photographs	Armor Unit Motion Surveys	Broken Dolosse Surveys	Current Speed & Direction	Littoral Environmental Observations	Photography/Video Tape	Photogrammetry	Salinity	Scour Surveys	Sediment Samples	Side-Scan Surveys	Structural Surveys	Tidal Prism	Tides	Topo/Hydro Surveys	Underwater Inspections	Wave Direction	Wave Height & Period	Wind Speed & Direction
Barbers Point	X					X								X	X	X			
Carolina Beach	X					X			X			X	X	X			X		
Cattaraugus Creek	X				X	X			X		X		X	X		X			
Cleveland Harbor	X	X	X			X				X				X		X	X		
East Rockaway	X				X	X			X			X	X		X				
Imperial Beach	X			X	X	X		X	X			X	X	X	X	X			
Manasquan Inlet	X	X			X	X	X			X	X	X	X	X	X		X		
Oakland Beach	X				X	X			X		X	X	X		X	X			
Puget Sound					X	X										X			
Umpqua River	X			X		X		X				X	X	X			X		

programs at the structures. Performance of the armor units at the two locations has been as different as the two structures. At Cleveland, monitoring has resulted in an understanding of the mechanisms affecting the movement and breakage of the armor units. The data thus helped the Buffalo District develop a repair plan for the breakwater head after it was damaged in a severe storm. While damage at Cleveland has indicated underdesign of the armor, a lack of damage at Manasquan Inlet has indicated an overdesign. Maintenance plans for the Manasquan Inlet jetties have been reevaluated. An evaluation of the dolosse performance data is continuing to identify the reason for the apparent underdesign of one unit and overdesign of the other (Pope, 1984; Pope and Clark, 1983; and Zwamborn, 1984).

Jarrett (1976) developed an equation to calculate the tidal prism of an inlet based on a modification of the classical work of O'Brien (1931). That equation has been tested at Carolina Beach, Manasquan Inlet, and Umpqua River. Measurements of the tidal prism have agreed well with the value predicted by Jarrett.

Often, models are used in the design process. Physical models of flows at Umpqua River and Cattaraugus Creek were used in the evaluation of alternative designs. The structural solutions selected and built have been shown to produce the prototype flows predicted by the models. At Cleveland Harbor, wave data collected during 1981 were compared with the results of a shallow-water wave hindcast model developed by CERC. The comparison showed that the numerical model can accurately describe time-varying storm wave conditions in spectral form.

Sediment budgets for the projects at East Rockaway and Carolina Beach have been compared to actual data and have been modified to better predict renourishment of the beach fills. This has been particularly useful at the 6.2-mile East Rockaway project. Data collected are being used to evaluate the procedures currently being used to establish sediment budgets.

An additional benefit of the MCCP Program has been the opportunity to test new monitoring techniques. At Cleveland Harbor and Manasquan Inlet, SSS was demonstrated to be an efficient and cost-effective, qualitative subsurface inspection technique for coastal structures. While it is particularly useful in turbid water where visual or video inspections are impossible, SSS can also significantly reduce the cost of inspections in clear water by identifying specific areas of a structure that require more detailed inspection (Patterson and Pope, 1983).

At Manasquan Inlet, comparison of photogrammetric and standard leveling techniques for measuring dolosse movement on the jetties demonstrated better agreement than anticipated. Photogrammetric techniques have more than adequate accuracy for a myriad of coastal engineering applications and, in many cases, significant savings can be accrued by using photogrammetric mapping as compared to conventional leveling (Gebert and Clausner, in press).

Although the program has already produced usable results, much more is anticipated. For example, data are being collected on the transformation of waves from offshore into harbors at Umpqua River and Barbers Point. New guidelines on the usefulness and design of sediment traps in coastal inlets will result form the work at Carolina Beach. Data collected both lakeward and shoreward of the Cleveland breakwater, an impermeable structure, will be used to test the overtopping design used in the rehabilitation of that structure. Dolosse stability has been observed at both the Cleveland breakwater and the Manasquan Inlet jetties. These data will be used, together with data from other studies, to further evaluate the stability coefficient used for dolosse armor.

SUMMARY

The need for a program to obtain performance data from prototype coastal projects has been recognized, and that program has begun producing results useful to the coastal engineering community. Reports on the first four monitoring efforts are in preparation, and eleven more projects are being, or are about to be, monitored. Results from the MCCP Program will be used to test the current state of the art and assist those who plan, design, construct, operate, or maintain coastal projects. Support for the program continues to grow, insuring its continued expansion.

ACKNOWLEDGEMENTS

The investigations described in this paper were undertaken by WES as part of the Monitoring Completed Coastal Projects, Civil Works Operation and Maintenance Program of the Corps of Engineers. Mr. John H. Lockhart, Jr., Hydraulics and Hydrology Division, Office, Chief of Engineers, was technical monitor for this program which was managed by Mr. John Mikel, Operations and Readiness Division, Office, Chief of Engineers. The author wishes to acknowledge the Chief of Engineers, US Army Corps of Engineers, for permission to publish this paper.

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DISCUSSION

PROF. WIEGEL: *I think it should be pointed out that on the existing wave system at least two of those in California are transmitted to the Corps and are published by the Corps but are not installed at Corps cost. One is a private corporation, Pacific Gas and Electric (PG&E), up near Diablo Canyon. The second, I believe, the one at the Farallon Islands is in San Francisco. My guess is the one up in Kauai, Hawaii, had to do with other purposes. But I'm using this because other portions of the country might be able to encourage local money to go into wave recorders, just like these few that I happened to mention, or money from other sources. Then the Corps cooperates with them and analyzes the data and puts it out in a form that's very useful for everybody. I thought we heard at the last CERB meeting that the State of Florida has funded wave recorders at several sites. Could you comment on that, please?*

DR. WOOD: Yes. It's a very good point to bring up. Actually, on the West Coast right now we have nine project gages which are the ones that you're referring to that have complemented the system. What we're showing in the existing proposed map are what we like as our long-term index stations. There are actually more dots that we could have on that West Coast map to show these types of gages of opportunity, I guess you would call them, and we do put all of those into the system. They're all brought in and they'll be in the archives. We do provide support to a degree, to the Coast of Florida Wave Gaging System, and we do have the wave statistic summaries put out from the Coast of Florida. Those are not gages which we have . We would simply contribute to that program so that we have that information in the system. That's why I didn't show them as existing Corps gages. They would fall, perhaps, in the same sense of operating gages of opportunity, which we participate in fully.

BG EDGAR: *I'd like to comment on the Alaska situation that Neil Sailing wrote in about and maybe, George, you might have a better sensing of that than Dr. Wood. We all understand the criticality of the Alaskan situation. I recognize everybody has tight budgets, but certainly the Alaskans understand as well as anybody the importance of those gages and their cost shared in this regard.*

Do we have any knowledge of why they decided to pull out of the cost-sharing business?

DR. WOOD: Let me defer to Mike on that. He has been talking directly to them with and has made a trip up there recently.

MR. HEMSLEY: The problem is directly declining oil revenues for the state of Alaska, which are the principal revenues for the state. They envision a continued decline in revenues, and they recognize that a lot of the programs that they've started are quite expensive. So the present governor has decided to take a very decisive step to bring the State budget into what he considers to be an under-control situation, and he's just made dramatic demands on the departments. He told the Department of Transportation and Public Facilities, which has provided the funds for the program, to reduce their budget by 50 percent. The budget they originally submitted was reduced by 50 percent from last year, and those folks have been scrambling to keep jobs and keep projects that they consider to be of particular importance. So our program has kind of gotten lost. It's a case of $250,000 probably not being enough to be noticed, so there's nobody to fight for it except Colonel Sailing. We've been doing as much as possible.

BG EDGAR: *All right. Then let me ask then the following question. If there is no source from Alaska, as there apparently is not, what are we going to do?*

MR. HEMSLEY: For this next fiscal year we're looking at trying to sustain a minimum system--keep a couple of the gages that we've got in place operating--and scurrying to try to find some additional funds. There is still some support from within the Alaskan Department of Transportation, and we're hoping that we can get some percentage of the support they've given before to help keep the system going in a reduced mode. It would be appropriate to include the Alaska program under the field wave gaging portion of the field data collection program.

BG EDGAR: I think Bob's comment a moment ago about seeking out around the coast of our country to see if there can be some cost-sharing partners in this regard is very important. We all know the difficulty that we've had in funding our own portion of this and coming up with sufficient moneys even on the limited scale that we have now. No one knows what the future is going to look like. It probably is not going to get any better, although it certainly might; but it seems to me that our coastal Districts and Divisions ought to press on with universities or with state governments to see if we can work out some kind of an arrangement that can be mutually beneficial because those data certainly are important. Maybe we ought to get out some letters from the Board or from the Center, Robert, to the coastal Divisions, and see if we can get something going.

MR HEMSLEY: The State of California, sir, is an excellent example. Not only do they support the field wave gaging program with a direct contribution, the Coastal Commission is the one who has directed PG&E at Diablo Canyon and the City of San Francisco with the Farallon Island buoy to bring their data into our system and just recently found that they are doing the same thing with a consortium of the oil companies. We're going to be getting some data from oil rigs.

BG EDGAR: Well, I notice for the first time that our friends from New England Division (NED) are not present, and I would lean on Tom Bruha and some of the others to get with MIT. Maybe we can work something out with them off the New England coast, and certainly there are other opportunities. California certainly is a good example. Bob may not agree, but I think California is probably wealthier than a lot of other states, too; and that's part of the problem.

PROF. WIEGEL: I've got another question.

PROF. WIEGEL: He thought it was going to be a rebuttal, but it isn't. We're poor, poor. On the wave hindcasting, I don't understand why it's necessary for the Corps to proceed on the Pacific Coast area, in California. There's very well organized and has been in existence for a long time a very good routine forecast for operational conditions that the oil companies use. It's very good. I don't want to get into certain comparisons, but with the predecessor of the existing one, it looked better. The data are all on computers. They have for certain specific places hindcast 60 major storms since 1900, mainly off San Francisco, off Diablo Canyon, and for several other places; and it seems to me it might be cheaper to get the information you need from something that's existing. Now I have nothing to do with the company. It sounds awful, but we've made use of it on projects; and it's really not clear to me why this is being done.

DR. WHALIN: *Let me answer that, and Dr. Vincent may want to speak to it, too. I think it may well be a good idea to take a look at the storm climatologies you were talking about, especially the 1960 storm, to see if we might not want to include that. Do you want to comment on that, Dr. Vincent, or did you hear the comment?*

DR. VINCENT: Since I recently rejoined your staff, I can only say that Pacific hindcast had been done in essence up to Phase III. It might be interesting to purchase the results and do a comparison.

DR. WHALIN: We'll look into that, especially for the storm population, Bob, because, of course, as you know, what we need the most is better extremal statistics and that might well be a good suggestion. We'll definitely look into it.

PROF. WIEGEL: Professor Borgman was in one site and took a look at the distribution functions. It has really gone one full step past there for a specific location, and for another location quite a bit of it is available. It's all on computer.

DR. WHALIN: I understand.

PROF. WIEGEL: And once you've made all these forecasts and you've brought them in for certain specific places right into the coast, it's not that difficult to bring them in for other locations. That was my point.

DR. WHALIN: No, that's very true. We'll take a look at that and let you know.

DR. WOOD: I might comment, too, that one of the reasons that the Pacific is of interest to us in the sense of getting the model developed is that is where we do have our greatest density of wave stations right now for the comparison. As Linwood suggested in comparing the two, but more specifically because we have here the ability to verify and test the model, we would be rather lost just going to the Atlantic with our sparsity of gages.

PROF. WIEGEL: The existing commercial thing was far better than the information on the amount of energy at the longer period waves. There is just no comparison.

DR. LE MÉHAUTÉ: *What is the status of the NOAA program and the cooperation with NOAA?*

MR. HEMSLEY: Well, using the needs of the Coast of California study we pressed ahead to start collecting data from NOAA's specific buoys. Right now we are collecting all the data from their buoys with the exception of those around Hawaii, and we're working on those. We hope to have those data put into our monthly reports fairly soon. Dick Seymour has been running back and forth to Japan recently and owes me just a brief cost estimate so that we can get that into the next contract.

DR. WHALIN: Bernie, the other NOAA program, you know, that Lee Baer used to be associated with doesn't exist any more.

PROF. WIEGEL: *Has that been done?*

DR. WHALIN: Yes, that has been done. They haven't been collecting any data for about 2 years now, and so the only NOAA data that are being collected are the data from the buoy office, you know, in Bay Saint Louis--the big buoys, the ones that Mike was talking about. Dr. Lee Baer has nothing to do with the waveriders any more; he's got some other staff assignment. They scrapped that program; it's not going to fly.

MR. KENDALL: *That's just going to be ongoing NOAA observations. It's not going to be the historical look back to make that data available in hard form?*

MR. HEMSLEY: We haven't tried to do that yet.

RESEARCH NEEDS IN THE LOWER MISSISSIPPI VALLEY DIVISION

CERB Proceedings

Mr. Cecil W. Soileau, Chief
Hydraulics and Hydrologic Branch
Engineering Division
New Orleans District

ABSTRACT

The coastal setting in Louisiana is both varied and fragile. Some segments of marsh are protected by sand beaches and barrier islands, while others have no protection from the elements which seek to ravage and destroy. This paper presents an analysis of the short- and long-term needs of the Louisiana coastal area. In the short-term, now to the end of this decade, our needs include wave climate prediction over vegetated marshes and over muddy, deformable water bottoms of inshore embayments and floating marsh; research into new surge prediction methods, both with respect to stage and frequency, at points far distant from the sea coast (30 miles and greater inland); and research into the best way to use offshore deposits of sand for beach and shoreline nourishment without aggravating current shore processes. Over the long-term, 30 to 50 years from now, research is needed on ways to best predict how the marshes of Louisiana, presently subsiding and eroding at an estimated 50 plus square miles per year, will change and on the impacts on two million coastal residents of Louisiana and the entire nation's economy.

INTRODUCTION

In this presentation we seek to bring the Coastal Engineering Research Board (CERB) up to date on what has happened in Louisiana since we last reported to you here in Vicksburg in November 1981 and to give you what in our view are needs unique to coastal Louisiana (Figure 1). Over the last 35 years Louisiana's coast had become much like the weather; everyone was talking about it, but no one was seemingly doing anything about it. But I am happy to report that someone, namely the Corps of Engineers and the State of Louisiana, is finally doing something tangible and perceptible about it. Listed below are the results of our efforts.

(1) The Grand Isle, Louisiana, and Vicinity Hurricane and Beach Nourishment Project has been constructed jointly by the state and Federal governments.

(2) A site for a freshwater diversion structure at Davis Pond in Jefferson Parish has been approved by local parish officials, and advanced engineering and planning for that structure will continue.

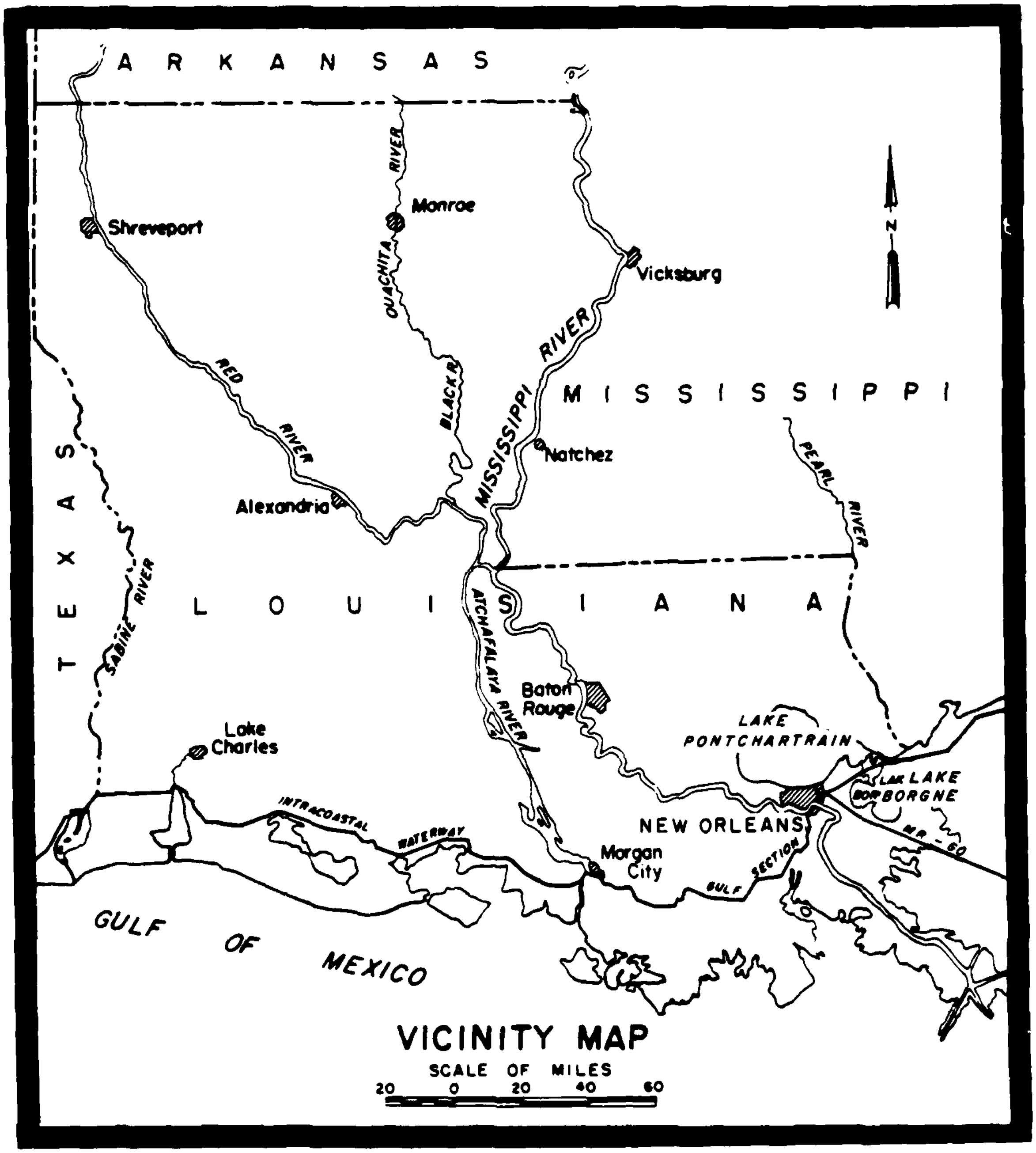

FIGURE 1. VICINITY MAP OF LOUISIANA

(3) The site for the Caernarvon freshwater diversion structure has been finalized, advanced engineering and design is moving along, and a request is anticipated for a new construction start in early fiscal year 1987 (FY 87).

(4) The Louisiana legislature has appropriated money to study and develop projects to protect marshes and barrier islands in Louisiana.

(5) The Louisiana State Geological Survey has already completed one barrier island beach closure project and plans very soon to create a new 280-acre island at the mouth of Shell Island Bay to replace Shell Island, destroyed by a recent hurricane.

(6) The Hydraulics Laboratory here has completed a long developmental modeling process and can now begin to predict Atchafalaya Bay deltaic growth and the effects of such growth on coastal processes.

(7) The New Orleans District will let the first contract for foreshore dike construction and subsequent bank nourishment in the Mississippi and Southwest Pass in the near future.

But these efforts are only the beginning, a narrow band-aid over a gaping wound. The root problem is that the Louisiana coast is sinking and washing into the sea from which it emerged in centuries past. Seven major delta lobes, occupied by the Mississippi River at one time or another, created coastal Louisiana (Figure 2). Now, deprived of the sediments that raised it

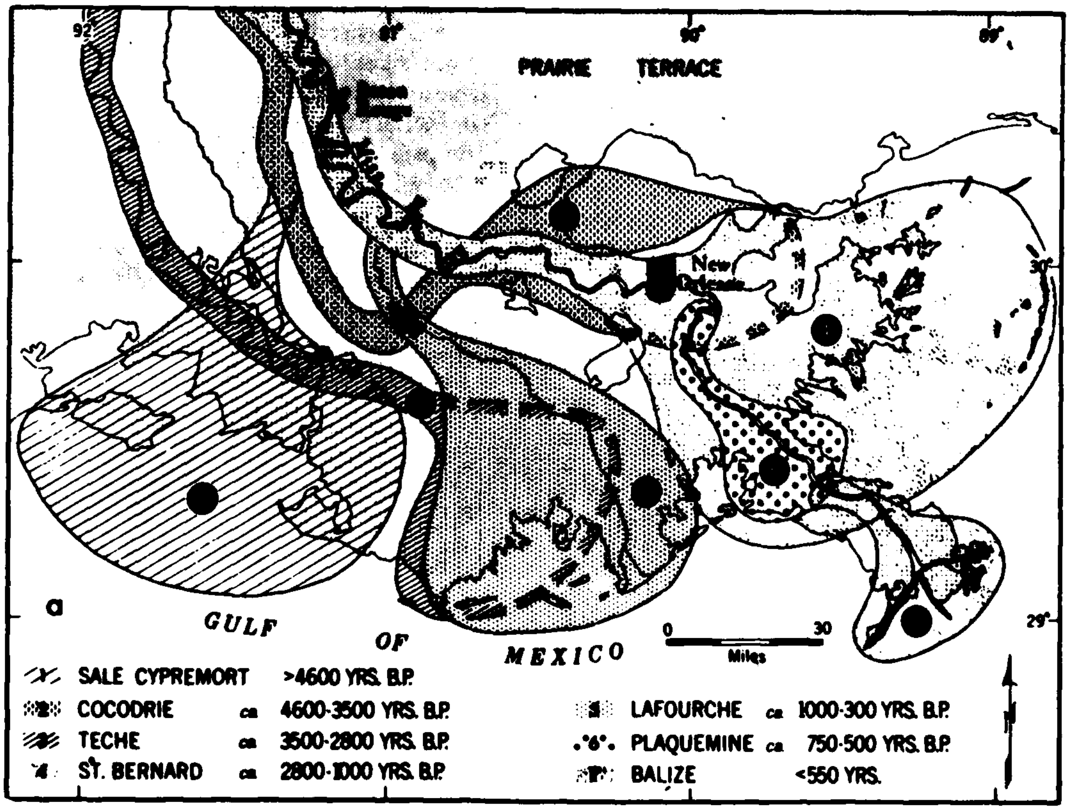

FIGURE 2. SEVEN MAJOR LOBES OF THE MISSISSIPPI RIVER DELTA

up and maintained it, Louisiana's coast is yielding to the forces of subsidence (or compaction), sea level rise, and erosion. This National Aeronautics and Space Administration (NASA) image (Figure 3) shows the enlarging open water areas left as the delta subsides. An example of changing land mass is shown in the two maps of the area of the Mississippi Delta in 1956 and 1978 in Figures 4 and 5, respectively.

Figure 6 shows the rates at which this part of coastal Louisiana is disappearing. Our findings about land loss indicate that even with a wholly impracticable reconfiguration of the Atchafalaya and lower Mississippi Rivers to divert all of the available sediment for building new land, much of the coastal land mass of Louisiana will cease to exist in the next 500 years. The dark area in Figure 7 is the coastal Louisiana land mass of 15,000 square miles where 1-1/2 million people live. A new technology is needed to increase our efficiency in utilizing the Mississippi's sediment for building land so that we can optimally manage those few areas of growing delta while trying to preserve the natural environment.

NEEDS IN COASTAL ENGINEERING

Immediate Short-Term Needs

Inshore Wave Prediction

The effects from muddy bottoms and floating marshes on wave heights inshore should be investigated. There is a need to identify the potential for wave energy transmission across marshes and shallow embayments where bottom sediments are primarily composites of silts, clays, and organics. There is a contention by Dr. Robert Suhayda (1984), Professor of Civil Engineering, Louisiana State University, that wave forecast techniques described in the Coastal Engineering Research Center's (CERC's) Shore Protection Manual (SPM) (1984) significantly overstate the potential wave heights and wave overtopping of coastal structures fronted by wide expanses of marsh of deltaic origin in Louisiana. Although the SPM cites this phenomenon as an important consideration in forecasting waves, it does not contain any theory on how it may be addressed by Field Operating Agencies (FOA's). Because there is lack of knowledge in this area, there is potential for overstatement of impacts in two areas. One is associated with setting the base flood elevation too high in semiprotected areas where existing levees are overtopped by waves.

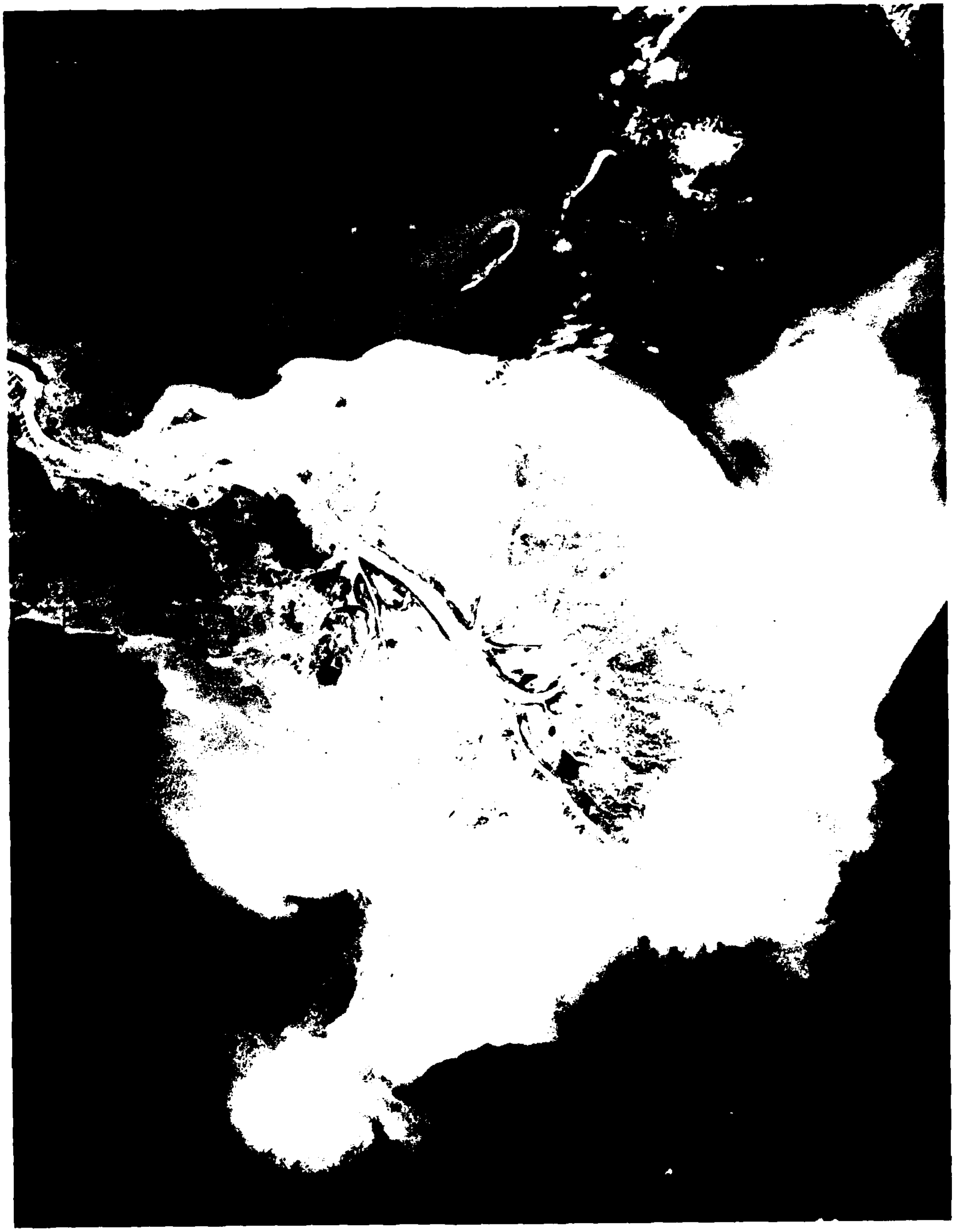

FIGURE 3. NASA SATELLITE IMAGERY OF THE MISSISSIPPI DELTA

FIGURE 4. MISSISSIPPI RIVER ACTIVE DELTA IN 1956

FIGURE 5. MISSISSIPPI RIVER ACTIVE DELTA IN 1978

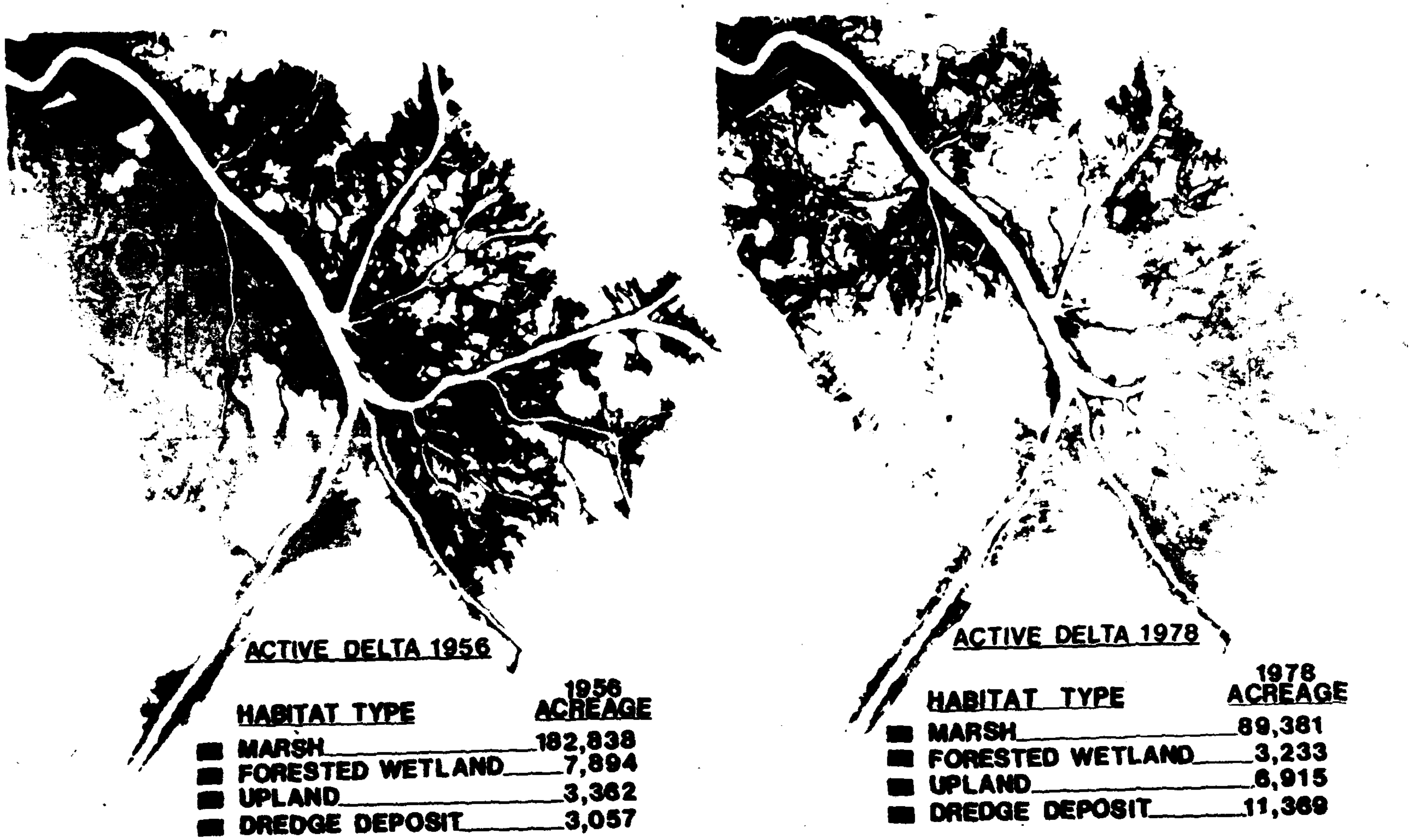

FIGURE 6. RATES OF ISLAND LOSS IN THE MISSISSIPPI DELTA

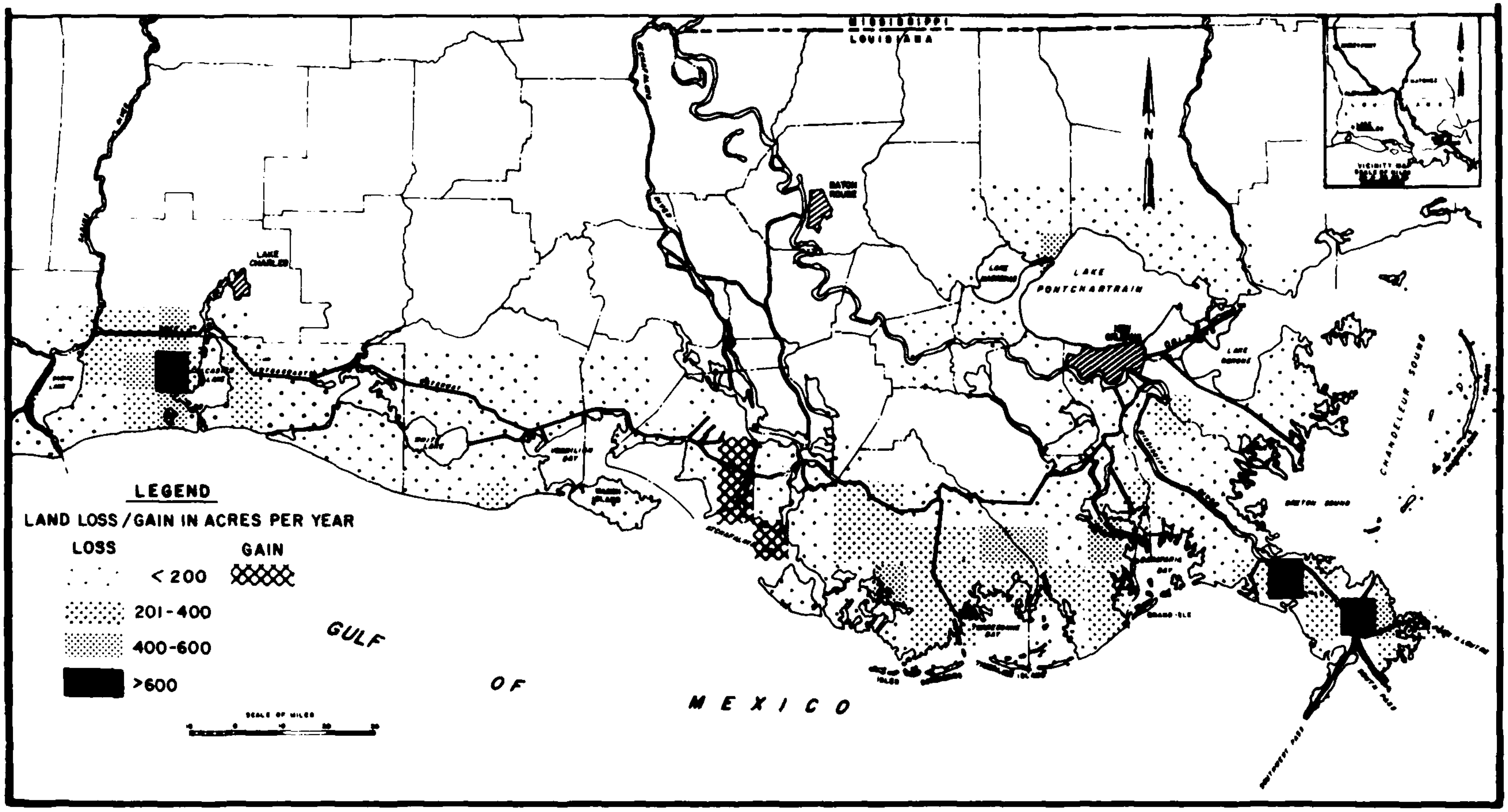

FIGURE 7. COASTAL LOUISIANA LAND MASS

Overestimation of the base flood elevation can raise flood insurance rates and cause new construction to build higher and at greater expense than necessary. This is a problem that spans the entire coast of Louisiana and spills over into adjacent states. The second area where overstatement is possible is in feasibility studies for hurricane protection. The flood potential may be overstated and, consequently, the benefits of higher levees may be overstated also if wave overtopping rates are exaggerated for an entire spectrum of events.

Inshore Flooding Frequency

A companion need to the one just described is the FOA's inability to forecast hurricane effects and frequencies of those effects inshore, in bays and tidal lakes connected to the sea, through tidal arms such as sounds or man-made ship channels, etc. Until quite recently, the capability to make projections of hurricane flood hazards was related to the availability of long-term historical data. Where data were sparse or nonexistent, the effects most often have been overstated and conservatively high, primarily because the inshore estimates of flood stage were arbitrarily assigned the same frequency as the open-coast event producing it. The problem stems not so much from the inability to forecast the hydraulic effect as it does from the difficult statistical and computerized analyses required and the high cost associated with those analyses. To perform a full spectrum analysis of tropical storms and hurricane effects in embayments, as many as several hundred to several thousand combinations of storm parameters characteristic of a given geographic region must be studied and quantified to adequately determine the flood hazard potential with any assurance. But even after this is accomplished, you have only a part of the answer.

Verification and Practical Application

Once the tools have been developed to forecast a spectrum of hurricane flood events inshore from the seacoast, research should be done to determine how marsh subsidence and loss will change the inshore wave and surge climate in seaside communities. The wide expanse of marsh which exists now in Louisiana provides for storage of phenomenal volumes of sea water in hurricanes, and the vegetation attenuates waves and limits their generation. The theoretical work performed by Dr. Fred Camfield (1977) of CERC, on vegetative effects on hurricane wave attenuation in Louisiana marshes, should be verified by actual observation. To achieve this verification, several transects should be selected along the coast of Louisiana where wave gages would be placed offshore, at the sea coast, and at two locations inshore in advance of the next hurricane event which should threaten the Louisiana coast. Such information is needed to quantify the value of marshes in ongoing studies to develop ways to enhance and preserve marshlands.

Beach Nourishment Practices

The Louisiana State Geological Survey has been given the task by the state legislature to develop marsh and barrier island protection projects in coastal Louisiana. There have been appropriated 43 million dollars for this purpose, and several beach and shore nourishment projects are scheduled to begin in the near future. The source of nourishment material is expected to be offshore borrow from suitable sites. However, in light of recent Corps of Engineers experience at Grand Isle, Louisiana, where offshore borrow material was taken for nourishment and some adverse effects have been noted in connection with this practice after only 1 year of operation, research is needed to evaluate the probable long-term effects from such borrow sources. What should be the optimum distance from shore for minimizing adverse effects from unbalanced wave energy transmissions? Is the change in shoreline at Grand Isle unique to it, or can this phenomenon be expected at other sites selected for its use?

Long-Term Needs

I mentioned earlier how important the Louisiana marshes are to the fisheries industry on the Gulf seaboard. It is questionable whether any of it will remain in 75, 50, or even 25 years, given the rapid rate of subsidence and erosion now taking place. Although there is a great amount of optimism in the academic community that the Atchafalaya River will continue to build a new delta into the Gulf of Mexico in the next three decades, that vision must be regarded as a hope rather than a revelation. Man's future need for water, the dramatic decline in suspended sediments in our rivers, the poor growth rate that the Mississippi and Atchafalaya deltas witnessed since the 1973 flood, and the chronic battle against regional subsidence and marsh erosion may slow the growth rate considerably when Gulf-generated waves begin to attack the blossoming delta with full force.

Consequently, we need a two-fold method to meet the challenges of future decades. First we must reverse those techniques developed in the Atchafalaya Bay Model of Delta Growth to predict how the Mississippi River Delta will decay and recede from the Gulf, for example. These modeling techniques already have included in them many of the forces active in the coastal environment with few exceptions. However, as I pointed out earlier, this approach is an optimistic one. In order to quantify the probable severe consequences of marsh erosion, land subsidence, hurricane flooding and wave effects, saltwater intrusion, water quality degradation, botanical conversion to less desirable plants, and rapid and severe shoaling of navigation channels, an air of pessimism is mandatory. Secondly, we need models, verified through hindcasts, which can respond to the following laundry list of forecast questions:

(1) How will the marshes recede, and how fast to one point or another?

(2) What will be the major cause or causes? Can these be identified so that man can plan for the future? Will it be due to hurricanes, or will the major cause be long-term sea level rise?

(3) Should coastal communities plan for the inevitable need to relocate due to encroachment by sea? Will hurricane flooding become worse with time? Will hurricane barriers be feasible? Can selective planting of vegetative cover lessen the impacts of hurricane waves and surge transmitted over the marshes?

(4) Can the Gulf of Mexico and Atlantic fisheries industries maintain the status quo, or is it likely to collapse in future decades due to loss of nursery areas in Louisiana? What would be the economic impact on the nation's seafood industry, and are we willing to forego this?

(5) How will the decay of the Mississippi Delta affect the sedimentation in the nation's number one port? Will it deteriorate faster than Congress and the Corps can fund and build corrective works? Will saltwater intrusion due to deltaic collapse and marsh erosion become so constant as to affect the freshwater supplies of two million coastal residents? Will the Houma Navigation Canal and the Calcasieu River Ship Channel to Lake Charles become too expensive to maintain?

SUMMARY

Developing methodologies to predict changes in the coastal area's physical and chemical parameters is an important step forward; however, scientific methods of translating the changing parameters into economic impacts are very much needed. Such factors as hurricane flooding, water supply, water quality, recreational fishing and hunting opportunities, and the commercial shipping, fishing, and trapping industries are some of the important functions of the coastal area from an economic viewpoint. For instance, a definite nexus exists between the physical and chemical parameters in the zone and commercial fisheries production. To date, most of our knowledge relating the parameters to such impacts are subjective and based on observations and expert judgment. More scientific methods of relating impacts and parametric changes are needed. It is important not only to be able to predict changes in parameters but also to translate these into impacts and express those in monetary terms. It is only through this process that we can justify enormous expenditures for improvements that will protect and optimize the coastal area.

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DISCUSSION OF FIELD TRIP, RESEARCH PROGRAMS, AND FACILITIES PLAN BY CERB MEMBERS

BG ROBERTSON: Well, I will start by again reiterating appreciation to the staff and the leadership at CERC for an outstanding tour. I thought the selection of the models that we saw was outstanding, and I, for one, was--even though I visited here six or seven times before--very impressed with the demonstrations they put on, particularly the operation of some of the models for the short period of time. So I think the entire staff is to be commended for doing a great job.

DR. LE MÉHAUTÉ: Well, I was very pleased by what I saw during these last 2 days. It gave me the impression that Phase I--if we want to call it that, or maybe it's Phase II-- which was to build up the movement of CERC, has been achieved; and I feel very comfortable. I think I expected it would take a much longer time after the move from Washington to build up the full capability of CERC, but the momentum is there. We need to keep it accelerated.

I think the presentation by Bob Whalin about the long-term future of CERC is well received. His presentation gave me the impression that he and the staff of CERC really want to create a center--I will even say an international center--of excellence. I think the potential is there.

In order to achieve this, we have to look ahead a little bit further beyond the existing program, which is excellent; but we have to keep trying to improve what is being done, and this will be done in two ways. The first one is improving the facilities. Bob Whalin has stated that CERC's facilities are excellent; and I will say they are good, but they could be better. I believe it is clear to all of us that CERC needs to improve its wave engineering capability by installing a programmable generator. Such a generator is a necessity. That's the first step.

So, we need to work to invest more in better and better facilities. I will even go a little bit farther than that. We need to identify what the needs are. In order to become a center of excellence--a national center of excellence--we need to create unique facilities. What I mean by unique is facilities which exist nowhere else. The snake paddle is a step in the right direction, although the paddle already exists someplace else. If we have a unique facility, we can do research which can be done nowhere else.

The budget constraints will not allow us to do it fast, maybe, but we have to plan ahead for the future. And maybe money will become allocated at a later date. For example, we can envision the possibility of creating a large three-dimensional wave tank with snake paddles and with tidal currents for studying littoral processes in the laboratory at this scale. This has not been done in three dimensions before. It will allow us a number of breakthroughs--research breakthroughs--which cannot be done anywhere else. We can envision extremely large wind wave tanks as to the direction, for example.

But I don't want to say that this is what needs to be done. I'm just giving an example of possible installations which may need to be considered.

I feel more and more a need for it since I see no opportunity to create it anywhere else in the United States because of the lack of support from other agencies and organizations. So CERC has not only an opportunity but also a duty to create that goal because it will not be done anywhere else.

This can be achieved not only by creating a staff of extremely good capability and having a unique facility but also by collaborating with other organizations and outside people.

I think, further, that more needs to be done to attract the participation of the academic community. In theory it is true that the academic community can come to Vicksburg and use this installation and participate in the research which is being done here, but maybe not enough is being done in this direction because maybe it's not attractive enough for the people to come here. I don't know what to do about it, but if we are going to attract more participants from the outside to Vicksburg, I think it will be very beneficial in order to make Vicksburg the center of excellence.

So I'd like to conclude that I'm very pleased with the progress which we have seen since the move from Washington. The progress has been very amazing, and I did not expect that CERC would reach that level of capability so soon. The presentations which were done were outstanding, and it gives us a feeling of confidence of the quality of work which is done here. But it's never enough. We have to keep doing more. I think we should draw up a long-term plan for the future and really make that laboratory the best center in the world in coastal engineering. I think it's possible. Thank you.

PROF. WIEGEL: Again. I want to state that I thought the presentations were almost uniformly excellent and well chosen. We got a very good idea of the spectrum of research that's being done. I want to just comment on a couple of the specific things again. The directional wave spectral generator has an opportunity now for at least a decade of very fundamental research of making use of it which I know you're planning because I talked to you and realize that you have many plans for it.

Secondly, I'll comment on the field study that is proposed at the Duck, North Carolina, facility. Again, I think this is excellent, and I do feel that somehow we've got to increase the exposure of the young engineers and scientists as rapidly as possible to get out in the field.

I just simply do not like people who have come out of a university to go immediately into a similar environment in a laboratory because they are liable to think that engineering and science consist of laboratories and computer printouts, but they do not. They consist of the actual projects, and these people should be exposed just as rapidly as possible to the field. Somehow I would prefer them to be employed by Districts or something like that first and then come in here. But, the alternative is what I know Bob Whalin s working on, and that's to get up to the Duck facility right away, to get out there and see the ocean as it actually is.

The expansion of data collection by the Corps of Engineers installing wave recorders is good. I hesitate to get into some of the other recorders because I've been connected with measuring currents and things of that sort, and the cost of operations just goes up tremendously. I doubt you'll get into that except on a specific project-by-project basis, but the encouragement of other agencies and companies to put in the hardware and then have the analysis and data promulgation be of the Corps' existing method of doing it I think is the best way of trying to share the money and get more of this done.

The field studies that we had a presentation on yesterday and a couple of phases, I think, have got to be continued and in some ways expanded through choice of a few specific projects. The one in particular which was mentioned during the presentation is the seawalls. It must be determined whether they should be vertical or sloping walls, or smooth or riprap walls. Also, the effect on beaches must be determined because I've seen several examples in which they perform quite differently from the way everybody in the world says they're supposed to perform. When you see something that performs differently from what it'supposed to, you don't understand it; and you had better continue to study it because these are the sorts of things that are the hardware that we eventually spend our money on, very large sums of money. We do not understand the processes that are going on in order to do a good design at the present time. Another example was the presentation on the barrier islands. That work should continue. Again, I think you should expand it, as I feel that we need more of the field work. That was a very good example of a field study trying to understand a very complex subject of which the barrier islands are a good portion of the east coast of the US and the Gulf.

I'm a bit worried about the overall research in the United States. I agree with Bernie that we want to be sure we have an excellent center, but unless NSF somehow expands in another decade, you're not going to have a source of people because if the facilities at universities aren't available, the faculty and the graduate students aren't going to do research in that area. They're going to do research in other areas, and you'll have very fine people who are being turned out. But they are going to be turned out in structural dynamics and geotechnical foundation problems, and there won't be very many in coastal.

I don't know how to address this. It's a Corps problem because ultimately you use them. But I don't really see what you can do except for the thing we discussed a little bit and that is to fund research--the basic research--outside, or at least a certain portion of it, so you can encourage the continual flow of new people into the area.

BG EDGAR: For my own part, there are three points that I'd like to discuss. First, since the move from Washington, as I think we have all observed firsthand here, Dr. Whalin has kept us apprised of how things were going, and the reports have always been upbeat, positive, and things were going well. I think that we are satisfied--not that we by any stretch of our imaginations thought that he was putting us on--that we have seen firsthand, and I think we are pleased with what we have seen. Things are going well. They could be better, but as Bernie so clearly pointed out, I think they're going much better than we, or perhaps even Robert, anticipated when the move came from Ft. Belvoir down to Vicksburg.

I think the opportunities that are now opened up to the Center as a result of being here in the WES family are just virtually unlimited. The interchange between the various technical areas that WES provides, I think, gives our coastal engineering folks not only new life and new opportunities but an opportunity as well to interchange their thoughts and ideas with the other members of the WES community, and that cannot help being a great big plus.

So I'm pleased with what I've seen, not only with the folks whom I visited with off and on over the last several years but also those whom I've met this time for the first time. To see all of you in your facilities getting on with the work has been heartening to me.

With regard to the facilities and to the report on the master plan, we all know that construction comes tough, particularly when we're fighting for

Plant Replacement and Improvement Program dollars. I think it's certainly my desire, and I think I speak for the Board, that we would like to keep involved in how things are going with the master plan of CERC and how things are progressing in the order of priorities as your facilities are being considered and as they move through the pipeline for ultimate approval.

If we are to do some of the things that Bernie described earlier, clearly we have got to have the facilities to do that. And so we would like to, I think, be kept up-to-date as to what the status of that work is.

Lastly, I wish to comment on the tours. I think that sort of ties in with the thought I mentioned earlier. I thank Colonel Lee and Dr. Whalin and the CERC staff for setting up the opportunity for us to see, in an admittedly very, very short time, key elements of the Center. We are delighted to have had that opportunity. Some of us have seen bits and pieces of it before. I'm, sure we are going to see it again, and I, for one, would like to spend more time in some of the areas we saw and some that I didn't see.

So what that really means is that we need to come back to WFS more frequently than we have in the past, but I think that's the responsibility of our Board members. Let's not wait for Board meetings. Let's come down and see how the folks are doing and share some thoughts with them during those visits.

COASTAL ENGINEERING RESEARCH BOARD
43RD MEETING, 22-24 MAY 1985
MAGNOLIA-BEST WESTERN MOTEL
VICKSBURG, MISSISSIPPI

COMMENTS AND RECOMMENDATIONS BY COASTAL ENGINEERING RESEARCH BOARD MEMBERS

Below are summaries of comments and recommendations by members of the Board. Appendix D contains letters with further comments and recommendations by BG Palladino, BG Robertson, Dr. Le Méhauté, and Professor Wiegel.

BG C. E. EDGAR III, CE

I believe that the coastal engineer in the Corps lacks identity. Visibility, perhaps, may be a better word. Most of our work involves activities along the coast. Most of the Corps work force in the Civil Works arena is assigned to our coastal Divisions, yet the coastal engineering community doesn't seem to have a clear identity as an organizational entity within the Corps.

I don't want to get into the morass of whether or not that organizational identity should be in engineering or planning or operations. That's not my point, because I think if we look around the Corps where there is an entity of coastal engineering, you could probably find it in either one of those organizational elements.

I believe that every coastal District and Division ought to have an organizational element identified as coastal in some form or another, as well as within OCE headquarters. We really ought to grow our coastal engineers. Now, how do we grow our other engineers? Well, we grow them in the District, and you bring them on up to the Division, and we bring them on up in OCE. We do that very well with our other engineering disciplines, and, indeed, we do it very well with civil engineers. But the folks that we're really concerned with, our coastal engineers--if they consider themselves coastal engineers--are within the organization; and there's no organizational element to which they can gravitate that is dealing, by and large, with the coastal issue. As they look up the organizational structure of our Corps family, I do not believe there is a sense of career progression which will enable them to see themselves as "preeminent coastal engineers" within the Corps family. Maybe I'm wrong in that, but that's my perception; and I don't think I'm alone in that perception.

I suggest that we need to make a very strong effort to grow our own, so to speak, and to afford them the opportunity to come to work here at CERC or within our coastal Districts and Divisions so that they can get experience in the field. Whether they stay with us or whether they don't--hopefully they will stay--they're still part of that coastal community.

There is a tremendous move by our national population to go to the seashore, hence some of the legislation that we've had relative to protection of that seashore. Yet, every year Mother Nature comes along with one storm or another, and the old coastal engineering problems are right there. I do not think we have enough trained coastal engineers within our country. The issues are great. We must have a reservoir of talent, and if we do not grow it I don't know who will. Consequently, one of our recommendations to the Chief should be that we have an organizational identity within the Corps that serves as a conduit toward recognition of the work of the coastal engineer.

A major point I'd like to touch on is "Murden's Mound," a phrase coined by George. Most of us in this room, I think, don't need a long discourse on the dredged disposal site issues that we have had within the last few years. As a result of a lot of work done here in Vicksburg, we are beginning to make progress on getting rid of the perception that dredged material equates with spoil and all the negative connotations associated therewith. We recognize that we have proved scientifically that better than 90 percent of the dredged material is good clean material worthy of disposal anywhere in accordance with the laws of our country.

Nonetheless we still have citizenry who have some problems with disposal of dredged material in the open waters, despite the fact that it meets all the tests for safe disposal. Bill's proposal is certainly a very valid one which clearly has to be pursued. We have some offshore mounds existing now in the natural which are serving essentially the same purpose that Bill's man-made proposal would provide. Consequently, I think we should put some resources into collecting data on what nature has already provided so that when we move forward with the proposals in other locations in a man-made circumstance we do so with a degree of knowledge, which we probably have now.

Bernie has spoken eloquently about a "center of excellence," and I certainly endorse that, as I'm sure that all the members of this Board do. The Board should consider also, in conjunction with the CERC staff, the short-term and long-term goals as we would like to see the coastal R&D program proceed. This is certainly not a one-time thing. It is something that is going to have to evolve. This can be done easily enough not only between our meetings but also in our regularly called meetings as an agenda item.

As long as we're talking about future agendas, I wish to echo what has already been said. I thought our presentations this time were uniformly excellent and very, very informative. I think we need to continue to have presentations by the CERC staff, as was done this time, so that we can have an understanding of how these work units are progressing and provide comments and, perhaps, some assistance along the way.

I think we need to look for new ways in terms of financing for gathering of wave data. Dr. Wood pointed out that if we go at our continued rate of expenditures, something like a hundred years, we'll probably never get there. That's tragic. Clearly we're facing a dollar crunch, and everyone understands that; but as I suggested yesterday, I think we have got to look to others for some help, whether it be work in-kind or whether it be dollars. In any event, we need to share the costs because what we come up with will be helpful to the coastal states where our data gathering facility is off their shores. It's a mutually beneficial exercise, and I think we ought to look for innovative ways to get the states' private enterprise, the universities, and whomever to become involved in the process. The beneficiary, of course, will be all of us because these data will help in so many ways to address not only the present problems along the coastline but also the future problems.

We talked a little bit after the REMR presentation, and I want to be sure that for the forthcoming budget testimony, in 8 or 9 months, REMR be a principal item of the remaining items portion of that testimony and that in the interim we, in the Research and Development Directorate and the Civil Works Directorate, need to get together to see what we can do to inform the Congress of our present progress.

Bory Steinberg made a point that I wish to underscore. He said, in effect, that we need to package our coastal projects which involve beach erosion differently. He also suggested that if there is flood control or any other feature that could be associated therewith, then we should proceed. Beach nourishment doesn't go very far in today's budget priorities, but if it can be demonstrated that what we are doing is tied in with the project that he talked about--Revere Beach in this instance--you then have an opportunity to serve the public and get that project off the ground.

I am asking all of our folks from the coastal Divisions to go back home and take a look at those projects that you have and at how you've presented them. If there is a way to present them differently from the way you have in the past to get them over the hurdles, then I think we should proceed.

We talked about model studies, and Bob Wiegel, I think, talked about a "bathtub study." It seems to me what he meant by that was a model study that provides a sense of direction. It is not a study in which all the answers are on the front end but one which allows a report to proceed to the point that when we get into the cost-sharing business with a local entity, they would be comfortable with the direction in which the project is proposed. So we need to think about new ways of doing business again. How do we go about doing that type of study that will make us feel comfortable as professionals but will not be costly in time and dollars?

Lastly, I think Dr. Whalin challenged us all with the questions in his presentation. All the Board members have copies of his presentation, and I ask them to please provide answers to those questions by 1 June. That's a short time frame, but it's important that we get the answers to those because I would like to get our proceedings out expeditiously. I would like to get our recommendations before the Chief early and, of course, get his response to what that might happen to be well in advance of our meeting in the fall.

To help us shape our direction it's important that we have your answers by 1 June so that we can pull them all together and work up a paper that can be presented to the Chief for his considerations. I ask you, please, to work hard to meet that deadline. I think in consideration of that, if we're talking about expanding what we're doing, I harken to what Bob Lee just said a moment ago and to what we have learned as a result of hearing our senior executive members of the Chief's staff speak to us earlier. We are talking about perhaps taking some dollars which are going to something else, so it becomes a priority matter. Maybe it's not quite a zero sum game, but certainly the impacts--if we are to do more than we have up to this point--are going to affect somebody else, which means an adjustment to that particular program unless we come up with a new way of generating dollars and support, as I mentioned briefly on the data gathering business.

We need to recognize the fiscal constraints that we have today. Maybe what your idea is won't fly today because of the fiscal constraints, but that doesn't mean it's not a good idea and one that can't be taken into account in the future. We want to try to chart a new course if we can, so let us not feel constrained by a lack of dollars; instead, let us recognize that there is a fiscal constraint.

BG GEORGE R. ROBERTSON, CE

We have a tremendous capability here which not enough people around the country know about. I have recently bypassed two assignments and had the honor of starting to phase down the MX program and the Saudi Arabia program in the East Division. Particularly, in the East Division, I was fortunate to have some outstanding ambassadors of construction who were able to go around the world in that area, the 22 countries of the Mideast, and let people know what the capability of the Corps of Engineers was and what the capability and willingness of the United States was to support their construction efforts for their own defense, for their own infrastructure, and their modernization programs.

I don't know how much of that we are doing, but I would recommend that Bob and the CERC staff look into a quick reaction group of people or a single person. I had one person in the Mideast Division who was extremely successful in finding out about a problem and telling how our organization could respond to that problem. He got tremendous response from that. In every coastal state around the United States there are problems. Many of these coastal Divisions and Districts spend huge amounts of money on problems, which, nevertheless, remain unsolved. Alaska is a great example. I believe that we should be more active, not only in feeling out or knowing about these problems but also in sending someone to tell what CERC and the Corps of Engineers can do. We should be more of a marketing agent not only to solve their problems but also to expand our own overall knowledge with some reimbursable funds. We could save many people a great deal of money by helping to solve their problems while at the same time helping our own situation by advancing the state of the art.

Another approach would be to become more involved in the various universities. I think there's a lot we can do. Normally when you do that they say, "Great! Give us some research money, and we'll put a couple of Ph. D. candidates on it." Conversely, I think we can offer our facilities to bring some of those Ph. D. candidates here to work with us in a student intern program, for example, and maybe we can advance some special type of research student support program where for a minimal investment we can get not only a great deal of return from their research capability but respond to Bob's concern over too many of our young engineers who are going into other fields because we and the industry are unable to keep attracting them in the universities. Too many universities are getting away from coastal engineering because the money isn't there to support it.

So I recommend that we request the CERC staff or Bob to look into the possibility of developing a small marketing capability for CERC.

I have a couple of comments that I will just toss out for consideration by the Board to recommend to the Chief of Engineers. We have heard some excellent presentations, and some ideas have been floated around, but I wish to formalize those a little bit. The first one I have on my list here is a great opportunity, I think, offered by Bill Murden's presentation. In fact, we talked so much about it in the social atmosphere, I've come to refer to that as "Murden's Mound." The offshore berm idea offers tremendous opportunity to solve several problems, one of the major of which is money. And the other one, one of our greatest problems that's developing now, is what to do with materials that are necessary to be dredged in the navigable waters and from the harbors as the deepening goes on. This offers a tremendous possibility to solve some great problems.

Yesterday as I listened to the immense national problem being caused by the subsidence of the Louisiana coast, I began to wish Bill could get all of his dredged material and take it to Louisiana. That might help a little bit. The problem in Louisiana, I believe, is a major national issue, probably worthy of a special program to be recommended by the Chief of Engineers through our administrative hierarchy to the Congress for special study. I would prefer that Professor Wiegel or Bernie comment on the way to approach such a massive problem.

Of course, a little parochial interest here--and I don't know how we can do it as a Board with recommendations to the Chief of Engineers--but I would like to see that the Alaska Coastal Data Collection Program continue. I will take a personal interest in that, and I will be visiting Alaska in the next 2 weeks. I will attempt to see Governor Sheffield and put the word in other appropriate locations to see what we can do to continue the Alaskan interest in that. But I believe also that we have a responsibility in the Corps, and I'll work on that to see what we can do not to lose the tremendous gains we have made in starting to develop some data in a very important part of the world, one about which we know very little. We have a great opportunity there to get some basic information.

The one other major note I took was on our discussion about getting ourselves caught in a "Catch 22," that is, we come up with a project, and we need information to find the appropriate solution to that project. Only then do we identify what the research needs are, and the project has to wait 3 or 4 years. I think we should devote a special effort to look at those 23 coastal related projects that Lou Blakey talked about, go back to their parent Districts, get those Districts to immediately identify those research needs, and then see what we can do in one way or the other--either CP&E funding, special funding, or some way that we can start now--rather than waiting until we get authorizations and appropriations to develop the basic data that we need in order to find the appropriate solution. I don't think we should wait until those projects are authorized and then get beaten over the head for taking another 10 years to build them.

PROFESSOR ROBERT L. WIEGEL

General Edgar brought up the question, "Where in the US Government could one look for a focus on coastal engineering?" It really seems like the Corps of Engineers is the logical location of this, and I agree completely with General Edgar. I think that somehow this should be pursued. You've got these very good facilities, the field work, the linkage, and this proposed regional workshop following the regional workshop up in the New England Division where you invite the members of the profession, from private industry, state, county, and so forth to participate. It's a step in that direction to show leadership to the profession in general. And I would really like to recommend, sir, that this be pursued very actively because I think it's necessary.

I want to emphasize "Murden's Mound." I think it's excellent. I think that is a real opportunity to make use of that thing and especially in this one specific area that he has mentioned where it would actually be less expensive to dispose of the dredged material in an offshore linear mound. In doing so you can get a full experiment and save money at the same time. I don't think it's very often that an opportunity like this comes about.

With respect to the Mississippi Delta I think our new Board member, Dag Nummedal, is the logical person to expand on that. I think it's really a national problem, and I think it's very fortunate that at this time the new Board member is somebody who's undoubtedly the most knowledgeable person there is on that subject to work with you on how to proceed.

When Dean O'Brien and Professor Johnson started the coastal engineering conferences, the people who were invited were engineers, geologists, physical oceanographers, and mathematicians because it was recognized that the problems were extremely complex and that one was not going to solve things by working by oneself. You had to have mechanisms to mix these different groups of people and to work jointly on the solutions, or first the understanding and then the solutions, to these problems. So I would like to second what Dag has mentioned there.

I want to make a sales pitch that the 20th International Coastal Engineering Conference, which is one mechanism for the mixing, is scheduled to be held in Taiwan in November 1986; and there will be field trips throughout the coast of Taiwan afterwards. I would like to recommend that the Corps of Engineers try to delegate a maximum number of people from WES, the operating Districts, and OCE to make use of this opportunity for the Congress to have the opportunity to look at some of the coastal problems of Taiwan, including the modern port developments. I have been out there a number of times, and I have seen their development of a couple of brand new ports with industrial complexes.

They were not natural harbors. The entire complex had to be made by massive breakwaters extending out into the ocean because of the geography of the region. Everything--all the infrastructure, highway transportation, and the factories--was being planned at the same time. I think it would be a very good opportunity for people to be able to see something that's been done very recently, very successfully.

As you know, the US policy--especially in the State Department--on technology transfer goes very heavily back to when Kissinger was Secretary of State; and there have been examples of very poor technological transfer. But there have been examples of superb technological transfer. The technological transfer that has occurred in some of the Asiatic countries, such as South Korea, Singapore, and Taiwan--I won't mention Japan because it has not been a transfer--has been an explosion, and Taiwan is one of these examples where it has worked superbly.

I said it last night, but I want to get it in the record. It has been great, and I have thoroughly enjoyed working with the Corps, the Districts, the Divisions, CERC, and WES over all these years. I think the Corps is a great organization. You've only been in business as long as the United States; and I suspect you're going to stay in business as long as the United States exists, especially when you keep looking for new directions and things of this sort.

I just want to thank everybody. I have enjoyed the entire time that I have been working here, and you're not going to get rid of me very easily.

DR. BERNARD J. LE MÉHAUTÉ

If you are in a party among laymen and people ask you "What do you do?" You say, "Well, I am a coastal engineer," and they say "What do you mean?" Then you have to explain what your profession is. Now if you are a naval architect, for example, and you say "Oh, yeah, I'm a naval architect," nobody asks you what you are talking about. So I think as a profession we are not recognized by the public at large. They don't even know that we exist. As a result, it has a lot of consequences because we have plenty of coastal engineering problems in this country, but we are not called when needed.

You see a lot of civil engineering companies in which civil engineers who are training in structures, or whatever, actually try to solve coastal engineering problems and put their professional engineer signature on them without having the training which they need to solve these problems. Then we are told by Pilkey, for example, coastal engineers are the worst in the world, considering the many bridges and seawalls that have been failing. But these seawalls were not necessarily designed by coastal engineers.

Then you say we need more coastal engineers. I say, yes, we need more coastal engineers to solve all these problems, but when you train a coastal engineer he doesn't necessarily find a job because of that lack of recognition he needs. So you want to train more students in coastal engineering, but it's not enough. We have to open up the market by aiding the coastal engineering profession, organized as a profession. I think the needs are plentiful but just not organized. I think we have completely failed in the profession from a public relations point of view by not being recognized as a profession and being called upon when we are needed.

I would like to add to the comments you made yesterday. I just want to point out how much I have enjoyed working with my two civilian colleagues, Bob Wiegel and Bill Bascom. It has been both a pleasure and a great honor to have such distinguished colleagues on the Board with me.

COL ROBERT C. LEE

I would like to make one comment, sir. As you and General Robertson know, the greatest resource constraint that exists at WES is manpower in the civil areas. For the benefit of the Board right now, the Waterways Experiment Station is doing about 200 man years of work in excess of our civil manpower authorization; and we have about a $40 million carryover. So although we want and we appreciate the support, to drive off in these other areas, there will probably have to be tradeoffs in other fields as we go along.

DR. DAG NUMMEDAL

I would like to express my thanks--I believe that is the proper word--for what the Corps has demonstrated in terms of extending its invitation for an expansion of the Board to the coastal, geological, and geophysical communities. I want to mention also the research program that's under way within CERC and the barrier island-related research and interactions within coastal engineering structures and the natural geological processes along the coast. I think that those of us in the geological community for a long time have felt that we have been looking at how nature wants to organize its sediments and its characteristics along the coastline and that designers of many engineering structures that have been in place there have, to some extent, inadequately considered the natural flow of the waves and the tides in the coastal zone. This inclusion of the coastal, geological, geophysical, and oceanographic communities for more active roles within the Corps' program gives recognition of the fact that we are all out there to try to save the same American coastline and that we try to look at it from our perspective in terms of the natural processes that have been molding it for a long period of time. We are trying to design future structures more in line with what nature is doing rather than in spite of the natural processes.

Also along that line, commenting on the research programs that are currently going on here at the Corps, I certainly agree with all the comments that have been made by the Board members earlier this morning. From my perspective, too, I would like to see the increased emphasis in the next 3 years on aspects of sediment transport to be movable bed modeling. I was very impressed with the tour yesterday and the facilities that I saw; yet, I would certainly like to have seen this particular research facility have a more active program in terms of movable bed modeling. I know Dr. Whalin is personally quite interested in this kind of modeling, too, be it physical models--like Dr. Le Méhauté suggested perhaps three-dimensional models where we do three-dimensional studies on interaction in currents and waves and also sediment transport--or be it computer models on sediment transport.

If there is any one aspect of the program that I feel needs to be expanded (in view of the understanding that we have of the dynamics of the coastal zone and our ability to predict what certain structures would do once they are in place), it would be the emphasis on sediment transport. After all, we are quite concerned about scour in front of seawalls, erosion of beaches, and changes in sediment circulation patterns across the ebb tidal delta caused by jetties. A number of those problems can be and, of course, are being addressed outside the Corps by studies of numerical modeling and movable bed modeling of sediment transport.

RESPONSE TO CERB's COMMENTS AND RESEARCH NEEDS

Response to CERB's Comments*

I think we need to have presentations by the CERC staff, as was done this time, so that we have an understanding of how these work units are progressing and can provide comments and, perhaps, some assistance along the way. I think we ought to pursue this Robert.
BG C. E. EDGAR III, CE

CERC will plan presentations on work units and CERC activities at all future CERB meetings. Since the fall CERB meeting will follow the "DUCK 85" experiment planned in September at our Field Research Facility, we will plan a presentation on the experiment in addition to presentations on work units.

I don't know how much of that we are doing, but I would recommend that Bob and the CERC staff look into a quick reaction group of people or a single person. I had one person in the Mideast Division who was extremely successful in finding out about a problem and telling how our organization could respond to that problem. He got tremendous response from that. In every coastal state around the United States they have problems. Many of them go out and spend an awful lot of money on those problems without really solving them. Alaska is a great example. I believe that we should be more active not only in feeling out or knowing about these problems but also in sending someone to tell what CERC and the Corps of Engineers can do. We should be more of a marketing agent not only to solve their problems but also to expand our own overall knowledge with some reimbursable funds. We could save many people an awful lot of dollars in helping to solve their problems and help our own situation in advancing the state of the art.
BG GEORGE R. ROBERTSON, CE

Making the public, state, and local governments, as well as other federal agencies, aware of the tremendous capabilities of the Corps of Engineers is a task we in the Corps probably all neglect to some extent. The problem is

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* CERB's comments are underlined.

a little less acute in coastal engineering because CERC is synonymous with coastal engineering in this country and throughout much of the world. Coastal engineering problems tend to be automatically directed to CERC which has tremendous one-stop service activity. Quite often the calls we receive, especially from consulting firms, are somewhat distressing because CERC personnel provide aid to callers from consulting firms who usually have salaries several times as large as those of CERC personnel; however, they often clearly know little or nothing about coastal engineering. Many of the well known coastal engineering failures are a result of designs by engineers who may be perfectly competent in their field but not in coastal engineering. Restrictions on Corps work for the private sector limit the aid CERC can provide. We have been active in supporting local and state governments, but manpower limitations in the Corps are likely to greatly restrict this support in the future. However, it is important to note that in other disciplines (e.g. environmental, geotechnical, structural) there are many organizations pursuing active programs, and local and state governments have a wide variety of choices if they cannot be aided by Corps laboratories. <u>This is not true in coastal engineering.</u> In many cases, if these governments do not receive aid from CERC, they have nowhere else to turn for expertise.

CERC has been trying to upgrade the expertise of state and local governments. For example, we have been holding training courses sponsored by the Federal Highway Administration (FHA) to instruct state transportation departments in coastal engineering. We recently completed a course for the Florida Department of Transportation and have been asked by the FHA to plan a similar course for a Great Lakes state. Our technology also is disseminated through presentations at the limited number of conferences covering coastal engineering. This is another area where the limited size of the coastal engineering field makes CERC a special case. Whereas in other disciplines small numbers of people can be sent to large numbers of conferences covering their areas of expertise, in coastal engineering CERC needs to send relatively larger numbers of people to the more limited number of coastal conferences. Although the percentage of CERC personnel attending conferences may be lower than that for other Corps laboratories, the relatively large numbers needing to attend the limited number of conferences usually cause problems. The International Conference on Coastal Engineering (ICCE), held once every 2 years, is a good example. Fortunately the last ICCE was in Houston, Texas, and CERC received permission for relatively large numbers of personnel to travel to the conference in a few vans. Future ICCE's are likely to be very sparsely attended by CERC personnel as a result of Out of Continental United States (OCONUS) travel restrictions.

Another approach would be to become more involved in the various universities. I think there's a lot we can do. normally when you do that they say, "Great! Give us some research money, and we'll put a couple of Ph. D. candidates on it." Conversely, I think we can offer our facilities to bring some of those Ph. D. candidates here to work with us in a student intern program, for example, and maybe we can advance some special type of research student support program where for a minimal investment we can get not only a great deal of return from their research capability but respond to Bob's concern over too many of our young engineers who are going into other fields because we and the industry are unable to keep attracting them in the universities. Too many universities are getting away from coastal engineering because the money isn't there to support it.
BG GEORGE R. ROBERTSON, CE

This is an excellent idea. Such a program would be of tremendous benefit to the student as well as to WES, the Corps as a whole, and the profession. We will investigate methods of implementing this concept.

I want to emphasize "Murden's Mound." I think it's excellent. I think this is a real opportunity to make use of that thing, especially in this one specific area that he has mentioned where it would actually be less expensive to dispose of the dredged material in an offshore linear mound. You can get a full experiment and save money at the same time. I don't think it's very often that an opportunity like this comes along.
PROFESSOR ROBERT L. WIEGEL

CERC has been excited for some time about Mr. Murden's innovative concepts relating to beneficial uses of dredged material. The cost of dredged material disposal is very great, and Mr. Murden's concepts allow use of a resource (dredged material) we can ill afford to waste. The Dredging Division of the Water Resource Support Center (WRSC-D) has worked closely with CERC on the "Murden's Mound" concept. CERC has monitored the demonstration disposal of dredged material at Dam Neck off the coast of Virginia Beach. This demonstration proved underwater berms could be constructed during normal dredging operation (with very well designed procedures for dredge operation) at no incremental cost to the government. In addition, CERC installed four current and wave instruments to obtain baseline data at a proposed disposal site where a berm construction was planned just north of Dam Neck. CERC further worked with the Norfolk District and WRSC-D in developing a study that would use field data and experimental and numerical modeling methods to demonstrate how the berm concept would have no adverse impacts on the coast and nearshore circulation. This effort has been put on temporary hold due to time constraints which have dictated disposal of dredged material at the interim disposal site at Dam Neck. However, we believe "Murden's Mound" is a concept that will become a key dredged material disposal method in future years, and CERC will work closely with WRSC-D to bring this tremendous cost and resource savings to fruition.

You see a lot of civil engineering companies where civil engineers who are trained in structures, or whatever, actually try to solve coastal engineering problems and put their professional engineer signature on them without having the training which they need to solve these problems. Then we are told by Pilkey, for example, that coastal engineers are the worst in the world, considering the many bridges and seawalls that have been failing. But these seawalls were not necessarily designed by a coastal engineer.
DR. BERNARD J. LE MÉHAUTÉ

This is a tremendous problem. No one would consider letting people with little or no expertise in the field design dams or bridges. Yet engineers with little or no expertise in coastal engineering are allowed to design coastal engineering projects. CERC agrees with Dr. Le Méhauté that given this sad state of practice, it is no wonder so many coastal projects designed by non-Corps personnel are failures. The coastal engineering profession has discussed this problem through the American Society of Civil Engineering (ASCE). However, since each individual state sets requirements for professional engineering certificates, it is going to be difficult to convince all coastal states to have professional coastal engineering certification. CERC has and will be aiding drives by professional organizations such as the ASCE to solve the problem expressed by Dr. Le Méhauté.

For the benefit of the Board right now, the Waterways Experiment Station is doing about 200 man-years of work in excess of our civil manpower authorization; and we have about a $40 million carryover. So although we want and we appreciate the support, to drive off in these other areas, there will probably have to be tradeoffs in other fields as we go along.
COL ROBERT C. LEE

Civil manpower authorization constraints may not only limit CERC involvement in new areas where our expertise is sorely needed but also restrict future support of local and state government. This would be a tragedy, since these governments have no where else to turn. CERC is the *de facto* center of excellence in this country for coastal engineering. The limited size of the coastal engineering field and CERC's historical role in the development of the coastal engineering field make CERC unique. There are multiple locations of expertise in all other major engineering disciplines. This is not true in coastal engineering. *The fact that the* Shore Protection Manual (SPM) is and has been for years the "bible" of coastal engineering worldwide (there probably is not a country in the world with sand beaches which does not rely on the SPM) is clear evidence of the special role CERC plays in coastal engineering.

I also want to mention the research program that's under way within CERC and the barrier island-related research and interactions within coastal engineering structures and the natural geological processes along the coast. I think that we have been looking at how nature wants to organize its sediments and its characteristics along the coastline and that many engineering structures that have been in place there have, to some extent, inadequately considered the natural flow of the waves and the tides in the coastal zone. This inclusion of the coastal, geological, geophysical, and oceanographic communities for more active roles within the Corps' program gives recognition of the fact that we are all out there to try to save the American coastline and that we try to look at it from our perspective in terms of the natural processes that have been molding it for a long period of time. We are trying to design future structures more in line with what nature is doing rather than in spite of the natural processes.

DR. DAG NUMMEDAL

CERC agrees wholeheartedly with Dr. Nummedal's assessment. The Barrier Island Sedimentation Studies work unit is our number one priority work unit in the Shore Protection and Restoration Program, and it is one of the highest funded work units at CERC. The Corps has taken to heart the criticisms of Professor Orrin H. Pilkey and others that the Corps has sometimes considered only engineering aspects of problems and not involved an interdisciplinary team approach which provides a total perspective. The problems of coastal engineering are very complex and require an interdisciplinary approach for proper solutions. CERC took this into account in its staffing-up program following the move from Ft. Belvoir to Vicksburg. Currently, in addition to coastal engineers, CERC has a very wide assortment of disciplines that can address the complex problems we face. CERC has coastal geologists, oceanographers, statisticians, physicists, mathematicians, computer specialists, instrumentation techniques, and a very wide variety of engineering disciplines. We approach problems using interdisciplinary teams so that all aspects of these problems can be properly addressed.

Response to LMVD's Research Needs*

Inshore Wave Propagation. The effects from muddy bottoms and floating marshes on hurricane wave heights inshore should be investigated.

Estimation of hurricane wave propagation over muddy bottoms and flooded land and in shallow-water embayments has not been rigorously treated. Until recently there was even a lack of methods for predicting hurricane wave conditions in shallow waters with sand bottoms. The problem is difficult because the winds change rapidly over short times and distances, and there is often a high variability of the characteristics of the flooded landscape. The marshland may not have uniform coverage of vegetation type, and there may be small channels, low levees, roads, and other highly complex topographic and

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* LMVD's needs are underlined.

bathymetric features. All these factors may affect wave heights markedly. CERC will propose a research work unit in the FY 87 program to address this need. LMVD should formally submit a requirement for this research in the Corps' Research Needs System.

Inshore Flooding Frequency. There is an inability to forecast hurricane effects and frequencies of these effects inshore, in bays and tidal lakes connected to the sea, through tidal arms such as sounds, or through man-made ship channels. The problem stems not so much from the inability to forecast the hydraulic effect as it does from the difficult statistical and computerized analyses required and the high cost associated with these analyses.

It is usually necessary to apply a Monte Carlo method such as the joint probability method to establish flood level frequencies for coastal projects. A large number of storms must be simulated to obtain the required data base. This computation can be made on a relatively coarse grid and thus is relatively inexpensive. To address the impact on coastal projects at the shoreline or even interior to the shoreline (e.g. over marsh area), a new statistical procedure has been developed at CERC and applied at Long Island, New York, and Roughans Point, Massachusetts. The technique uses a small subset of the open coast ensemble to accurately represent the flood frequencies on a more refined nearshore model grid. Computations on a refined nearshore grid for Long Island required computations of only 51 events (surge plus tide combinations) to obtain the desired confidence bands on the stated frequency results. This new approach would greatly reduce the cost of computations for inland flooding for the complex coastlines of interest to LMVD.

Verification and Practical Application. Once the tools have been developed to forecast a spectrum of hurricane events inshore and from the seacoast, research should be done to determine how marsh subsidence and loss will change the inshore wave and surge climate in seaside communities. The theoretical work performed by CERC on vegetative effects on hurricane waves should be verified by actual observation. Verification would be achieved by placing wave gages along several transects along the coast of Louisiana from the shore to the inshore.

Hurricane surge levels can be determined inshore using the techniques mentioned in the discussion of the inshore flooding frequency research need. Determining flood levels resulting from marsh subsidence and loss is not a research topic; rather it is the application of existing tools to site-specific projects. The theoretical work performed by CERC on vegetative effects on hurricane waves was simple and preliminary. We will evaluate methods for improving this preliminary work and explore potential resources for performing the work. Hurricane surge level measurements are being performed under the Hurricane Surge Data Collection work unit at CERC. Three gages have been installed off the coast of Louisiana on offshore oil platforms. Other locations have been established for installation of gages just prior to hurricane landfill. CERC will investigate establishing locations along transects where gages would be installed just prior to hurricane landfall. There may be practical difficulties in establishing these gage locations in marsh areas, since there are typically no solid structures to which gages can be attached and very low land elevations and limited accesses may make gage establishment difficult just before arrival of a hurricane.

Beach Nourishment Practices. The Louisiana Geological Survey (LGS) has been given the task by the state legislature to develop marsh and barrier island protection projects in coastal Louisiana. There have been appropriated $43 million for this purpose, and several beach and shore nourishment projects are scheduled to begin in the near future. The source of nourishment material is expected to be offshore borrow from suitable sites. However, in light of recent Corps of Engineers experience at Grand Isle, Louisiana, where offshore borrow material was taken for nourishment and some adverse effects have been noted in connection with this practice after only one year of operation, research is needed to evaluate the probable long-term effects from such borrow sources.

CERC has met several times with representatives of the Coastal Protection and Coastal Geology Programs of the LGS concerning the development of marsh and barrier island protection projects in coastal Louisiana. CERC has offered LGS assistance in developing project plans and design. In addition there have been discussions of several areas of possible cooperative work. The areas include cooperative geomorphological research; beach-fill design, evaluation, and implementation; monitoring and evaluation of coastal structures; coastal data base management; data collection; and applications of numerical models. CERC and LGS have already shared data collected in field programs at Terrebonne Marsh, Louisiana. Grand Isle is a site being monitored with CERC assistance under the Monitoring Completed Coastal Projects Program. CERC has proposed to the US Army Engineer District, New Orleans (LMN), a mission support study to investigate causes and assist LMN in developing solutions to erosion at Grand Isle.

Long-term Needs. Models, verified by hindcasts, are needed to forecast decay and recession of the Mississippi River Delta, marsh recession, effects of hurricanes and long-term sea level rise on land recession, the feasibility of hurricane barriers and vegetative cover to reduce hurricane impacts, port sedimentation, and saltwater intrusion.

Research is being conducted at CERC on long-term evaluation of barrier islands and marsh systems. The Barrier Island Sedimentation Studies work unit is one of the largest work units in the coastal program. Geographic models are being developed to understand long-term evaluation of landforms as a result of both long-term sea level rise and short-term storm events. Also, CERC has been developing a Regional Coastal Numerical Modeling System to consider coastal processes on a regional scale. Current plans are to apply this modeling system to investigate coastal processes along the coasts of California and Florida. The coast of Louisiana has many distinguishing features, but such a regional scale modeling system would have applicability in studying a variety of problems along the Louisiana coast. Other laboratories at the Waterways Experiment Station are performing research related to long-term research needs of LMVD. Saltwater intrusion and sedimentation of riverine ports are under investigation by the Hydraulics Laboratory. Use of coastal vegetation to protect dune systems and thus increase flood protection is under development at the Environmental Laboratory (EL). The Coastal Ecology Branch of EL conducts vegetative planting investigations at CERC's Field Research Facility.

DISCUSSION OF DATE AND PLACE OF NEXT MEETING

BG EDGAR: *Do we have anyone who would like to offer an invitation for this Board to meet in the fall?*

BG ROBERTSON: Yes, Mr. President, I think North Pacific Division (NPD) and South Pacific Division (SPD) are getting together. Mr. Ace Wanket, I think, has something to say.

BG EDGAR: Our distinguished representative from SPD.

MR. WANKET: Thank you, General Edgar. On behalf of General Palladino, SPD would be pleased to host the CERB meeting in the fall. And, more than that, we ask that the CERB meeting be combined with a proposed regional SPD/American Society of Civil Engineers (ASCE), coastal design conference that we are planning. Later on this morning I'd appreciate an opportunity to describe this to the Board.

BG EDGAR: *Are there any other offers of places to meet? Yes, sir, distinguished representative from Southwestern Division (SWD).*

MR. DEBRUIN: General Edgar, our Galveston District would like to offer an invitation to host one of the Board meetings in the Galveston District. We would prefer not to compete against SPD and NPD in the fall. About that time Galveston would be hosting a regional PIANC meeting at Corpus Christi, and members of this organization are urged to attend that meeting.

BG EDGAR: *Okay. I take it then you're perhaps holding out an invitation for a meeting a year from now?*

MR. DEBRUIN: That would be better. Yes, sir.

BG EDGAR: *Any other invitations?*

(No response.)

Ace, if you have a presentation, maybe we'd like to hear about that now.

MR WANKET: General Edgar, members of the Board, ladies and gentlemen, at our Chicago meeting General Palladino and General Robertson alluded to a proposed joint coastal design conference that we were thinking about at the time. I'd like now to report to you on the status of that conference and give you some dates and perhaps an interrelationship with the next CERB meeting. The conference we're proposing, the Bay Delta Model in Sausalito, which is just across the Golden Gate Bridge from San Francisco, is on the 7th and 8th of November. We would precede the conference with a half-day field trip, consisting of a boat tour around the Bay looking at the Fisherman's Wharf project and other harbor points of interest with a dinner on the 7th of November. The sponsors are NPD, SPD, and ASCE (more specifically, the Waterways, Port, Coastal, and Ocean Division).

The action people from NPD and SPD on this are John Oliver from General Robertson's staff and Hugh Converse from General Palladino's staff. Our intent is to involve all Corps Districts across the four coasts, private engineering consultant firms, societies, academia, and state and local governments. I have to, at this point, say that we're thinking in terms of about a hundred or so folks; and I fear that before we're done we're probably going to have more than a hundred. So we may have to rethink the location of the conference because of this. We picked our location for the bay model that is now in San Francisco.

We would hope that the CERB could meet on the 4th through the 6th of November. That's a Monday, Tuesday, and a Wednesday. The field trip that we just mentioned would be Wednesday afternoon, and then the workshop would be on the 7th and 8th of November. That is our thinking at the moment. We would plan to have the conference on the 7th and 8th of November, even if the CERB were not able to meet at that time.

Our format is to look at four sessions, each half day dealing with these four topics: structural design, harbor and channel design, coastal processes, and construction, operation, and maintenance activities. Typical sessions would be introduced and identified by a member of the Corps. State-of-the-art summaries would be given by Corps staff which would consist primarily of the Coastal Engineering Research Center Staff.

BG EDGAR: *Ace, would this be similar to specialty conferences?*

MR. WANKET: Yes, sir.

BG EDGAR: *Would ASCE publish the results of these workshops?*

MR. WANKET: Yes, sir. That's our intent right now. We're working with ASCE to publish the results of the workshop, but I don't think we've gotten that far yet.

BG EDGAR: I see.

MR. WANKET: *We have talked to the president of ASCE, who is interested in participating, and we will be announcing this through the ASCE news. I will ask John Oliver and Hugh Converse if they can answer whether we've gotten far enough to identify the proceedings of the conference or whether they would be published through ASCE. Have we addressed that at all yet?*

MR. OLIVER: We've addressed it, to a degree. We either wish to publish through ASCE or at least have the conference published as part of the Coastal Engineering Information Analysis Center (CEIAC) through CERC. Either way it will have a wide distribution.

BG EDGAR: A thought came to me in talking with both the president of ASCE and their executive director as well as with the folks with whom we dealt when we had the dredging specialty conference last year, which drew a lot of folks from outside the Corps and from the rest of the Federal establishment. My feeling is that's what you want to do here. One of the concerns that we raised in this was putting a focus on coastal engineering and the individuals who are involved in that and trying to grow, if you will, coastal engineers within the civil engineering professional category.

If we could, in the course of this, get ASCE to come up on board, have them publish this as a proceedings of a specialty conference, and get them involved in some of the chairmanships of these elements, I think we then have the opportunity to start something that may have a long-term effect. I would suggest that you all consider that and just leave it at that point.

MR. WANKET: That's a fine thought, and we might look at that.

PROF. WIEGEL: I did organize a few years ago a specialty conference, not in coastal engineering, but on directional wave spectra via an international group and ASCE. ASCE published it, but what we had to do was to include a charge to the participants so that they had front money.

BG EDGAR: That was our experience with the specialty conference last year in which the registration fee covered the entire operation. Every registrant had a copy of the proceedings given them which turned out to be two volumes, and it was very well received. It seems to me that would be a great thing for this opportunity that you're describing.

MR. WANKET: I agree, and we'll certainly look at that. We have not addressed in detail at this point registration and this sort of thing. General Palladino has had one conversation with the president of ASCE wherein he, from his status, agreed to cosponsor the affair with us; and then Hugh and, probably, John have had conversations with the local chapters of ASCE in these preliminary arrangements.

BG EDGAR: Good.

MR. WANKET: We're about ready to get out with the workshop announcement, soliciting participation from a full Corps and ASCE mailing list. Just yesterday General Robertson and General Palladino signed the letter for soliciting interest. That will be going out rather quick. We have a 1-month period for response. The program media on the 10th of July is rather key. We hope at that time to start selecting the papers, and our plan there is to involve the top coastal person in each of the involved Districts and CERC to help us select those papers which will be presented.

These are the sponsoring Corps organizations: NPD, SPD, Los Angeles District, Alaska District, Seattle District, Portland District, and San Francisco District. By way of summary, we planned a conference covering two and a half days, including the half-day field trip, having the principal purpose of information exchange on topical areas from Corps and non-Corps participants.

BG EDGAR: *Questions by members of the Board? George?*

BG ROBERTSON: I probably would like to make a comment a little later since we have this opportunity for practically a one week devotion to coastal engineering problems. We might consider a restructuring of our CERB meeting which will precede the original conference. I was going to suggest that later we solicit comments from the members to take advantage of this particular opportunity to concentrate our specialty papers and the technical papers at the workshop and then perhaps have more time to devote to policy issues, funding issues, and recommendations to the Chief of Engineers for our own programs. Maybe we should have a half day in a relatively closed session with the Board and with selected senior people at this conference. I would suggest, Mr. President, that you ask for comments from the Board members about how we can take advantage of this situation and maybe devote a little more time to policy issues and and recommendation issues in the research community and for CERC activities.

BG Robertson: On the 20th of July meeting, I think, when you set up the program, I suggest we invite our civilian members, those who are available, to sit in on that and to get academia interested also.

MR. WANKET: Okay. I will ask John Oliver and Hugh Converse if they would like to add anything to the information I just passed out.

MR. CONVERSE: I wish to ask the Board if they would like to possibly consider--assuming we are able to maintain the two meetings together--if a combined field trip would be in order, or if we should possibly have separate field trips for the members at the conference. Of course, that would be answered later, but you can consider that.

BG ROBERTSON: I think it should be combined on that field trip if the boat or boats are large enough. It will be a great opportunity to interchange information which can lead into good discussions at the following meeting.

MR. WANKET: Needless to say, that activity would reduce the logistics for our planning considerably.

BG EDGAR: *That boat tour is the morning of the 6th?*

MR. WANKET: Well, I'm not sure. We said the morning or the afternoon of the 6th.

BG EDGAR: *That is the last day of our Board meeting?*

BG ROBERTSON: Right. We would have to adjourn the Board meeting and then join the regional workshop members for the tour.

MR. WANKET: I have to put a little caveat on that boat trip. November is just on the edge of a weather condition. In that time we could have good weather or we could have bad weather. We would obviously need some sort of backup plan.

BG EDGAR: Sure.

PROF. WIEGEL: I attended the Permanent International Association of Navigation Congresses (PIANC) meeting that was in the Port of Oakland in November or October of 1984. And it was very successful because the only way you see a port is from the boats. The Coastal Engineering Research Board, as far as I can remember, has not had a technical tour of a port, and this is the whole reason why we have harbor entrances. It's not just to build structures and dredges, it's because there are ports at the end of it, and I think that would be very useful having gone through one in that area. I can guarantee it would be of extreme interest to everybody.

MR. WANKET: We have a rather good relationship with the Port Director at Oakland, who happens to be the former District Engineer out of San Francisco.

PROF. WIEGEL: That's why it was so successful last time.

BG ROBERTSON: *Should we consider—and I throw this out as a question, not as a recommendation—the ports of Oakland and San Francisco as cosponsors? There's money there if we need funds to support this, perhaps, plus the national additional support we would get for the boat cruise. Bob Robertson sure would be very interested; however, that might take it too far afield from our real purpose of coastal engineering.*

BG EDGAR: Why don't you all, as the organizers of the whole affair, pursue that as you see fit. I certainly think we've got a wonderful opportunity to link the session of this Board and that which you're describing in the workshop, which I think is a logical followup of some of the things we've discussed both in session and individually during the course of our meeting here.

I take it from discussions by members of the Board we are amenable to accepting the invitation from our two coastal Divisions on the West Coast for our fall meeting. When do you have to know, Ace, whether these dates are firm with the Board membership because we do have some members who are not here?

MR. WANKET: We should know by July or so. The logistics are what I'm concerned with. We have to plan more firmly in, I would guess, a July or August time frame. We still have an opportunity to adjust our program, if you choose not to come to San Francisco or to have a different date.

BG EDGAR: Why don't I say that we accept. We will confirm dates after Robert can poll the members of the Board.

MR. WANKET: Okay.

BG EDGAR: If there's a problem, then we'll worry about it at that point, but let's say that we will join you in that regard and thank you very much for the opportunity and the invitation and to Ron Debruin and those from SWD. We will file you at the top of the list for the meeting 1 year from now.

MR. WANKET: Thank you very much.

PUBLIC COMMENT AND DISCUSSION OF SOILEAU'S PRESENTATION

BG EDGAR: The next item on the agenda is public comment. When we left off our discussion yesterday from the Lower Mississippi Valley Division (LMVD) we cut off Cecil Soileau from his question-and-answer portion because there was a tie in, we understood, with what members of the public would like to share with us this morning. So I would like Cecil to make any other comments he might wish to make at this time. The law requires that we have the public comment during the time that we identified in the Federal Register, and that was scheduled to start at 0900.

MR. LOCKHART: I would like to add just a few other things. I was happy to hear you say something about wind generators because after the program review the other day I said to Doug Outlaw, "Well, now Doug, you've got the spectral wave generator running. Let's don't sit on our laurels. Move on to something better and greater, and maybe that should be wind generators."

I would like to make everyone aware that we're going to have a workshop on the Coastal Field Data Collection Program in August during which we're going to try to get all the field people together. It has been about 10 years now, so we're going to have a review, and maybe try to project the direction we're going to take in the future. I would like also to ask the civilian members or the Board as a whole to look not only at the research we are currently doing but also to look at the that which is backed up. I would welcome assistance in selecting new work units that should be started up as opposed to those that can wait a little while longer, if and when we ever get any new money to start some new work units. I think we definitely need to put our best foot forward.

MR. SOILEAU: General Edgar, I have only one comment. In the area of inland flooding from hurricanes, I mentioned yesterday a need for addressing that program. I also pointed out that the problem has been addressed at the coastline fairly well. The hydraulic effects of the coastline are fairly well defined by existing models. However, at great distances inshore on the Texas and Louisiana coast, and perhaps elsewhere, it is difficult to assign frequencies to flooding events associated with tropical storms and hurricanes; and I think that we need models that can do that for us, not so much the hydraulic effects I pointed out but the statistical analyses that are needed to determine just what the flooding has absorbed. The speeds of hurricanes, as well as their sizes and central pressure, can cause different stages even though they might be on a very similar track. That's a very important thing for us because in the future as the marsh erodes, the coastline will come closer and closer to our communities, and the flood hazards will change. So we would like to be able to predict what will happen in the long term.

One thing that Joan Pope pointed out to me the other day was that the Navy has decided to locate a major base at Pascagoula, Mississippi. I think maybe they were vying for various ports along the Gulf Coast, and I think Pascagoula has been selected. It's my understanding that one of the islands there that protects the entrance to the Pascagoula Ship Channel, for example, is eroding quite fast, and it's important to be able to predict what the facilities will have to be now and then what they may have to be 30 years from now because erosion might just wipe away any coastal barriers that might exist.

I would like to see CERC move in this direction to try and predict what flooding hazards are inshore from the coast. That's all I have.

BG EDGAR: Thank you, Cecil. Comments or questions by members of the Board.

COL LEE: *I have one, sir. Cecil, could you refresh my memory on the difference in the stage elevations that can be obtained by the Corps and the Federal Emergency Management Agency (FEMA) for flood stages caused by tropical storms in the Gulf?*

MR. SOILEAU: Well, I think probably the outstanding example is in the metropolitan New Orleans area. For example, we obtained descriptions of what standard project hurricanes should be in our design of the coastal hurricane barriers for the metropolitan area of New Orleans. Our levees have been designed to grades of 18 to 22 ft, for example, facing Lake Borgne. The National Weather Service, using that same intensity of storm, has been able to generate stages on the order of 24 ft, which is above the greater of our levees. And it's really not the meteorology that's giving the difference; it's the models.

In one case you're using rather conservative average values, and in the other case you're using extremes. And, of course, this is an extreme example. In cases of a less intense storm, the difference is not as great. But down in Plaquemine Parish, for example, which I think maybe Colonel Lee was referring to, we've computed, based on historical data, hurricane levels around 14 ft in lower Plaquemine Parish along the Mississippi River. And FEMA, in doing its flood insurance studies, actually tacked on to that wave or to the crest of the wave. At one time they were promoting base flood elevation about 19 ft as opposed to our 14, which again is a rather great difference. The question has been raised whether a wave that high can be supported in the marsh because of the vegetation which tends to attenuate the effects on the waves because of the roughness.

COL LEE: Thank you, Cecil. There are three aspects of that which are very important to all of us. One is assuring that we're protecting the people. The next is the economic impact, a difference of a few feet in elevation in the base flood level, and finally the confidence of the American people in their engineering profession. The fact that three Federal agencies can come up with three different flood elevations--probably for good reason--would cause me to support our doing some work so that we can come up with a model we can all agree upon.

BG EDGAR: Good point, Bob, and well said. Bernie.

DR. LE MÉHAUTÉ: I think it's absolutely true that a fault which has been devoted to the calculation of storm surge statistics and flooding risks in the New Orleans area is one of a magnitude less than it has been some place else. And the reason is the following: The FEMA activity on the other coastline has been very intense because most of the coastline was relatively simple. By holding, for example, 300 cases of storm surge for each county would amount to establishing a fairly reliable storm surge statistic through the joint probability method. Now if we were to apply the same method--the joint probability method--to the New Orleans area, it would not require 300 cases. It would require maybe 3,000 cases because of the complexity of the connection between Lake Pontchartrain and Lake Borgne, and this work has never been funded. The mathematical model of storm surge in the area has been developed, I believe, at Vicksburg by Lee Butler. The model exists, but it has never been applied in a statistical sense because of the tremendous cost that this would involve. And so FEMA has not provided the funds to establish a level of reliability on storm surge statistics equivalent to what they have done along the US coastline any place else. There is, however, something which has always been a little bit surprising. I will mention two points. The first one is the Corps project was presented with a cost-benefit ratio, if I remember, of 14 or 16. Now if you have a cost-benefit ratio of 14 or 16, it is underdesigned by definition. I mean it should be closed out to anything.

The second point concerns the dike which was built around Lake Okeechobee by the Corps of Engineers after we had the hurricane with some flooding of the farms and loss of lives. Of course, we acted immediately and built a huge dike around Lake Okeechobee when there is a very limited population around it. If you compare the size of the dike of Lake Okeechobee and the size of a dike around New Orleans you might say, "Well, we are putting our money in the right place." There's an inconsistency there.

So I'm extremely conscious of the magnitude of the problem and the risk involved in the situation at New Orleans presently, but I don't think the people of New Orleans are conscious of it. Actually when you are born and live there you never think it could happen. But I think all of us realize that something will happen one day, and it will be a very serious catastrophe if nothing is done about it.

BG EDGAR: *Are there members of the public present who wish to speak? I also wish to ask them to come forward and identify themselves so that our recorder will know who they are and whom they represent.*

MR. BEHRHORST: Thank you, General Edgar. Members of the Board, coastal engineers, and others, it's good to be here today. My name is Vernon Behrhorst. I am here today as the secretary of the Louisiana Intracoastal Seaway Association.

First of all, General Robertson says Louisiana is a national problem. I could take that in a number of different ways; but in the context in which it was made, I think we agree with you, and that is the reason why we are here. I say we, because Dr. Joseph Suhayda is with me today, and several others had hoped to be here. Dr. Chip Groat, who's in charge of our coastal protection program, as well as Dr. Shirley Gagliono, who is one of our eminent coastal resources authorities in Louisiana, was supposed to look at various aspects of that. A lot of what I'm going to say has already been said, but I will try to be brief.

Yesterday, when I was looking at the presentation of the "DUCK 86" program, I saw all those monitors out in the Gulf. It reminded me of a place where I was day before yesterday, down on the Louisiana Gulf. I saw the waves out there and all the wave monitoring equipment. Where I was on the Gulf in Vermilion Parish would have been an ideal spot to test that equipment. About a half mile offshore the waves were 3 to 4 ft. At the beach the water was as glassy as a swimming pool. There was not a breaker in the whole thing. It was just a constant dampening of the waves as they moved shoreward. It is a good example of some of the local sediment problem issues which we need to look at in coastal Louisiana.

We certainly solicit your help. We ask you to come down and help us, and if you can't "bring Mohammed to the mountain, we will bring the mountain to Mohammed" up here in Vicksburg where we're so delighted to have the Coastal Engineering Research Center. In fact, we're bringing a bus load of Louisiana people to WES this coming weekend, and I hope that you will let them know about the coastal engineering research program up here.

There are several things I want to bring to your attention in a general form, and I'm going to emphasize them. Down in Louisiana the problem--the national problem, if you will--has been perceived by so many people so long. But now that it is upon us, those same people who perceived it as a long-term thing that may or may not come are the ones who are on the forefront of wanting to dump rocks on top of everything to stop the problems that we have. That is not the solution either. We need a mix of things. But there is an urgency about what we need. We're talking about a 50-year lifespan of much of the coast of Louisiana right now.

I know you heard a presentation earlier about people moving to the coastal area. Many do not have any knowledge of the coastal area. We're looking at an issue of survival. In fact, some of us are even talking about the development of a survival line on the Louisiana coast based upon the availability of the best oceanographic engineering, geomorphological, sedimentological, sociological, and biological information. Activities seaward to this line should be only those that you're functionally dependent upon, being on the coast or in the adjoining wetlands. They should be in such a way that their life span would not exceed the predictable viable existence of this area. There, of course, would be areas within fingers of our natural levee system. Islands along the cheniers could exist in this area as well.

The safety of the people dictates that we look at something along these lines, and this is one of the areas that we are asking that CERC/CERB look into, working cooperatively with State and local authorities. It is obvious here we need lots of baseline data. But how much baseline data do we need, and how long down in our area can we stand in gathering these data? The decisions have to be made on some of these areas most quickly. We need to look at new methodology, modeling, and so forth, to handle these things.

We need to look at structural design, which I will get to in just a moment. We need them for storm protection, for coastal erosion, and something which has not been mentioned much here, wetland management, which is a broad term. To put it another way, I see CERC moving past the beachline. Cecil spoke earlier about the storm surges many miles inland. I believe that you have to reorient your mission, if you're going to work in our area more toward what is going on in the wetlands shoreward of the beachline. And we ask you to consider this. This would be a major step forward in your assistance to us in Louisiana.

This brings up structure design because it's something that I'm primarily interested in and which Dr. Sahayda will talk about. We build lots of structures. We have a billion dollars' worth of structures in Louisiana built by the Corps of Engineers--not a billion, but billions. But we need to look at inexpensive structural measures. We're going to need many of them to save Louisiana's coast. Also, I think, with more and more cost sharing coming in, there will be a real need for reducing the cost as for as the local people are concerned. After all, a lot of this is cost shared on a 50/25 or 75/25 basis. They've talked about navigation. Some of the bills are being proposed at 100 percent local participation. We need your engineering assistance, but we need to look at inexpensive structures.

The concept of building firm, rigid structures that will last for generations through a 1,500-year project lifespan, I think, needs to be reevaluated. A lot of them have to be movable due to a combination of organisms, navigation, and vertical changes in water levels whether they be due to tidal waves or sea level changes. Don't build them and then have to throw them out so they can accommodate these vertical changes; they have to be constructed to accommodate changes in volume of flow as well. You've got to maintain a constant weir crest to accommodate organisms and for other purposes so that it can be expanded.

Also in this whole concept we have to think in terms of expendability of structures, not just going back to the things built in concrete with bronze plaques on them in 1980 or 1984 which are expected to live to the year 2000. We need to look at the expendability of them. We also need to look at such things as levels of protection. Do we need 100 percent protection? Maybe it's wise to give only 50 percent protection in such an area to reduce the cost, if nothing else. Likewise, do we need 100 percent control of water management in a certain area as well as in another? These questions need to be addressed in more detail, but I'm just bringing them to your attention.

These are matters that are not unique to us, but they are a major concern to us. I just want to give you an example. Later on this morning I am meeting out at WES with some of your engineers to seek help with an immediate problem down there. We're looking at putting a bypass channel around the freshwater bayou lock to get some large structures out. They won't go through the lock because it's too narrow. They need 125 ft. There are only 84 ft. It's got to be done and designed quickly. This is not a Corps structure. The lock is the Corps' structure, but local interests have to do it because we can't wait for the long time required by the Corps. The method must be reliable and inexpensive. It must provide also for movement of the structures on repeat occasions and be easily modified if we want to make the channel wider. This is an example of some of the things we're looking at together today to meet our needs down in this area.

This is just a capsule form that I want to bring together as some of our needs down there, and I'm delighted that the issue has been brought to a head earlier in this meeting, and the response I've gotten has been very good as well.

I thank you, and I look forward to working with you on this. Thank you, General.

BG EDGAR: *Thank you very much, Vernon. I might say if you have written comments that you would like to provide for the record, we can accommodate that as well as your verbal remarks.*

Are there any questions or comments by members of the Board?

PROF. WIEGEL: I'd just like to comment that what you've said I think fits right in with what General Robertson has been talking about. There has to be a substantial change, in that the local contributions are getting larger and larger and especially this turnaround time. You might like something 10 years from now, but you want something much quicker than that, and somehow this great length of time necessary for these other projects to get going has to be reduced.

MR. BEHRHORST: I agree 100 percent with that and, of course, we recognize that having reliable baseline data is desirable; but sometimes decisions have to be made without having all that information. We are in that precarious situation right now.

BG EDGAR: *Are there other members of the public that would like to make a presentation?*

COL LEE: Yes, sir, we have one.

BG EDGAR: Good.

DR. SUHAYDA: Thank you. My name is Joe Suhayda. I'm an associate professor at Louisiana State University in the Civil Engineering Department.

Well, a number of speakers have addressed the issue. I hate to go over the same ground--the muddy ground--again. My interest, from the academic standpoint, is trying to meet the responsibilities of practicing engineers for technology and tools that are really going to work. I've been involved with studies of waves over muddy bottoms with oil company offshore design projects. The Federal Government recognizes it in terms of permeating offshore platform designs. There is an extensive amount of literature on this muddy bottom effect. It has not been carried into shallow-water areas, and--more importantly, I think to the Corps and to some of the people that I work with within the parishes--there aren't available verified engineering tools that are associated with a certain level of confidence. We could at the present time take information from the scientific literature. In fact, unfortunately, there are several options you have in terms of models. But I don't think that a scientific tool really meets the requirements of what we call an engineering tool, and I think it's generally acknowledged and certainly appropriate that the Corps of Engineers is the authority on the design and design specifications for these flood protection works and waterway control works.

So what we're really asking is that we would like to participate with you in helping you to reach what you feel are the appropriate design procedures. The State of Louisiana is doing work in the coastal zone, and it will continue. The problems aren't going to go away. After this conference I go back and meet with the people in Plaquemine Parish, and the problem is right back in their laps again. So there's an urgency here; but we can't, I think, step around the requirements that the engineering profession has for quality methodologies and quality designs. What I would hope is that the efforts that the Louisiana parishes , the State Government, and the universities would put forth could be and would be in cooperation with the efforts of the Corps. Cost is a factor for everyone nowadays, and, of course, if we can find ways to share the cost I think we'll be that much better off. I had some other remarks, but I think so much attention has been focused on this problem that it is really a little bit of overkill to continue. I just want to thank you, as a little bit of an interloper here, for the opportunity to meet with you. I have learned quite a bit, and I have appreciated being here. So thank you very much (see Appendix F for additional comments by Dr. Suhayda).

BG EDGAR: *Thank you very much. And I would quickly say that you are not an interloper. We are delighted to have you and anyone else from the general public who would like to meet with us and share your views. I would hope, too, that some of the things that we've talked about in terms of getting more local involvement in coastal engineering issues fell on fertile ground, so to speak. Clearly I think that is the intent of this Board and the Center to get local communities, professionals, academia, and government involved in what the very real issues are that are facing us along the entire coastline of our country. And until we get that involvement, we're going to have the same difficulties that we very clearly can see from a historical perspective. We've all got to do better, and no one can do it alone. We're in this thing together, and the sooner we all recognize* *that the sooner we'll get to the solutions that we need.*

So thank you very much for your comments. If you have something you would like to provide for the record we would be delighted to include that within the minutes of our meeting.

Do any members of the Board have any comments or questions?

PROF. WIEGEL: I agree with you completely about the effective waves over the soft muddy bottoms. We don't have--as I think you stated--recognized design procedures, and I think we must get those very rapidly. I want to thank you very much for bringing it to our attention.

DR. SUHAYDA: Thank you for the opportunity.

BG EDGAR: *Thank you, sir. Are there any other members of the public who would like to make presentations at this time?*

(No response.)

Let the record show, please, that there were no other members of the general public who would like to make a presentation.

Before we adjourn the meeting, I would like to express thanks on behalf of all the members of this Board to the WES community, and especially to the Center for the warm hospitality and courtesies that you have shown each and every one of us during the time that we've been here. I really think that this has been a most productive meeting, and in the 4 years that I've been on this Board, I think this is the best meeting that we have had.

I'm very encouraged about what we have seen here relative to the ideas that have been put forth that will help us to perhaps chart a new course with the concurrence of our Chief. We certainly have, I think, the basis upon which to give him some recommendations for his consideration, and I look forward to pulling all those together and getting with him in that regard.

I said last night my thoughts about our two members of the Board who are with us for the last time in an official capacity as members of the CERB--Bob Wiegel and Bill Bascom. We certainly appreciate their very strong support of what we are about, their guidance, their ideas, their pushing when necessary, and, most of all, the comradery and professional togetherness that we have had. Most assuredly, neither one of them has seen the last of this Board, and Bob has indicated that we're not going to get rid of him. That's certainly good, and I think were Bill here, he would say much the same thing. We recognized Bob last night officially, and we will certainly do the same for Bill at the earliest opportunity. We thank both of you for your efforts on this Board, and we look forward to a continued, though somewhat different, working relationship in the years ahead.

Be there no further business, I declare this meeting of the CERB adjourned.

BIOGRAPHICAL DATA

WYLIE K. BEARUP

CPT Bearup is the deputy program manager for the Repair, Evaluation, Maintenance, and Rehabilitation Research Program at the US Army Engineer Waterways Experiment Station in Vicksburg, Mississippi. He is a graduate of the Engineer Officer Basic and Advanced Courses and has served with the 78th and 326th Engineer Battalions and with Headquarters, 7th Engineer Brigade. He holds B.S. and M.S. degrees in civil engineering from the University of Arizona and is a registered professional engineer in Virginia.

LEWIS H. BLAKEY

Dr. Blakey, as chief of the Planning Division, Civil Works Directorate, Office, Chief of Engineers (OCE), is directly responsible for civil works planning affecting the environment and economy of all the 50 States. During 1962-1965 at OCE he directed a research program to improve hardened ground support facilities for ballistic missile defense systems. After teaching civil engineering at Catholic University of America, he became chief of the US Army Engineer Division, North Central (1971-1976). During 1976-1978 he served as technical director of worldwide facilities engineering mission for the Army, and during 1978-1980 he was Chief of the Office of Policy, Civil Works Directorate, OCE. He has received the following degrees: B.S.C.E., University of Notre Dame (1954); M.S., George Washington University (1962); Ph. D., Catholic University of America (1971); and M.B.A., University of Chicago (1974). He is a member of numerous professional organizations and is a registered professional engineer in the States of Virginia, Illinois, and the District of Columbia.

CHARLES C. CALHOUN, JR.

Mr. Calhoun is assistant chief of the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Prior to joining CERC in 1984, he held the following positions at WES: manager, Environmental Effects of Dredging Programs; manager, Dredging Operations Technical Support Program; manager, Disposal Operations Project, Dredged Material Research Program; and project engineer, Geotechnical Laboratory. He has been the recipient of various awards, including the

Director's Research and Development Award in 1979 and the ASCE Moffatt-Nichol Harbor and Coastal Engineering Award in 1984. Mr. Calhoun holds professional membership in the American Society of Civil Engineers, the Engineers Club of Vicksburg, the World Dredging Association, and the Permanent International Association of Navigation Congresses. He has been a lecturer and an instructor of various Corps of Engineers and university courses, and he has a long list of publications to his credit. Mr. Calhoun is a registered professional engineer in the State of Mississippi.

ROBERT A. COLE

Mr. Cole is a research structural engineer in the Structural Mechanics Division of the Structures Laboratory, US Army Engineer Waterways Experiment Station (WES). He has been employed at WES for 11 years, in which time he has been involved in the structural analysis of various military and civil works projects, particularly finite element modeling. Recent project experience includes work on the floating, sloping breakwater and seismic response of concrete gravity dams. Mr. Cole graduated from Tulane University in 1967 with a B.S. degree in mechanical engineering. He received an M.S. degree in engineering mechanics from Virginia Polytechnical Institute in 1974. He is presently working on his dissertation in computation methods for his Ph. D. He is a registered professional engineer in Virginia.

LLOYD A. DUSCHA

Mr. Duscha is currently serving as Deputy Director of Engineering and Construction, Office, Chief of Engineers (OCE), Washington, DC. As the senior civilian engineer, he provides the technical direction on policy matters of national significance and on major engineering and construction decisions. Also designated as the Corps of Engineers Dam Safety Officer, he is the Department of the Army's representative on the Interagency Committee on Dam Safety and the chairman of the US section of the Columbia River Treaty Permanent Engineering Board. Prior to assuming this present position, he served as chief, Engineering Division, Directorate of Civil Works, OCE, Washington, DC; chief, Engineering Division, Missouri River Division office at Omaha, Nebraska; and chief, Engineering Division, Philadelphia District. He served as chief, Engineering Branch during construction of the Atlas D and F Intercontinental Ballistic Missile sites in Nebraska and the Minuteman I and II sites in North Dakota. Professional affiliations include membership in the US Committee on Large Dams and past chairman *of the Executive Committee; the American Society of Civil Engineers; the National Society of Professional Engineers; and the Society of American Military Engineers. He has a B.S.C.E. degree from the University of Minnesota and is a member of Tau Beta Pi and Chi Epsilon honorary fraternities. He is a registered professional engineer in Minnesota.*

CECIL G. GOAD

Mr. Goad has served as chief of the Operations and Readiness Division (formerly Construction-Operations) in the Office, Chief of Engineers (OCE), US Army Corps of Engineers, since August 1981. Prior to that, from January 1977 to August 1981, he was chief of construction-operations of the Corps' South Atlantic Division. Before that he was Baltimore District's chief of Construction Division for 2 years, and he spent 13 years in military construction in OCE. In his present position, Mr. Goad is responsible for managing the operations and maintenance of the Corps' civil works projects and developing policies and providing technical guidance to the Corps field operating agencies in the execution of their programs. He has been personally involved in some of the major military and civil projects of the Corps, including Walter Reed Army Hospital, the Richard B. Russell dam and power plant on the Savannah River, the Tennessee-Tombigbee waterway, and a highly sophisticated wind tunnel complex at the Arnold Engineering and Development Center of the US Air Force at Tullahoma, Tennessee. Mr. Goad earned the B.S. degree in civil engineering at Virginia Polytechnic Institute. He is a member of the Senior Executive Service.

VERNON K. HAGEN

Mr. Hagen is chief of the Hydraulics and Hydrology Division (H&H), Directorate of Civil Works, Office, Chief of Engineers (OCE), US Army Corps of Engineers, Washington, DC. He started his Federal career with the Bureau of Reclamation in 1951 and joined the Corps of Engineers in 1953 at Ft. Peck District. He moved to OCE in 1958. Mr. Hagen is a 1951 graduate of Montana State University with a B.S. degree in civil engineering and a 1969 graduate of Catholic University, Washington, DC, with an M.S. degree in civil engineering. In January 1979 he became chief, H&H Branch, which became a Division in May 1983. Over the years he has authored over 12 publications and has received 6 awards, including the Meritorious Civilian Service Award. He is a registered professional engineer and a member of three ASCE committees and nine intergovernmental or international committees.

J. MICHAEL HEMSLEY

Mr. Hemsley is a research hydraulic engineer, US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center (CERC), Engineering Development Division, Prototype Measurement and Analysis Branch. He has been employed with CERC as either an Army officer or as a civilian for 9 years since 1973. During his time at CERC, he has been principally involved with the development and conduct of monitoring/data collection efforts. He currently manages two national data collection programs, the Monitoring Completed Coastal Projects Program and the Field Wave Gaging Program. Mr. Hemsley graduated from Johns Hopkins University with a B.E.S. degree in geophysical fluid mechanics and from George Washington University with an M.S. degree in harbor, coastal, and ocean engineering. He is a member of the American Society of Civil Engineers, American Shore and Beach Preservation Association, and Oceanic Society. Mr. Hemsley is a registered professional engineer in the Commonwealths of Virginia and Pennsylvania.

JAMES R. HOUSTON

Dr. Houston is chief of the Research Division, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). He has worked at WES since 1970 on numerous coastal engineering studies dealing with explosion waves, harbor resonance, tsunamis, sediment transport, wave propagation, and numerical hydrodynamics. He is a recipient of the Department of the Army Research and Development Achievement Award. Dr. Houston received a B.S. degree in physics from the University of California at Berkeley, an M.S. degree in physics from the University of Chicago, an M.S. degree in coastal and oceanographic engineering, and a Ph.D. in engineering mechanics from the University of Florida.

GARY L. HOWELL

Mr. Howell is a hydraulic engineer in the Prototype Measurement and Analysis Branch, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES), a position held since November 1983. He received the B.S. and M.S. degrees in electrical engineering, both from the University of Florida. He has held engineering positions in industry with IBM Corporation and Honeywell-Bull, France. He served as assistant director of the Coastal Engineering Laboratory at the

University of Florida until 1983. While there, Mr. Howell developed the Florida Coastal Data Network field wave and storm surge measurement system. He has served as a consultant in the areas of coastal and ocean instrumentation and maintains current research interests in the development of advanced instrumentation and data analysis techniques for coastal and ocean engineering. Mr. Howell is a member of the Institute of Electrical and Electronic Engineers and Eta Kappa Nu. He is also a registered professional engineer in Florida.

JON M. HUBERTZ

Dr. Hubertz is a research oceanographer in the Coastal Oceanography Branch, Research Division, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station. He has been employed at CERC since 1976 working primarily in the areas of numerical modeling and remote sensing. He has worked on problems of storm surge generation, coastal circulation, shallow-water wave transformation, and the prediction of nearshore waves and currents. He acted as the remote sensing coordinator of the center from 1982 until 1985.

STEVEN A. HUGHES

Dr. Hughes is a research hydraulic engineer in the Coastal Oceanography Branch, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station. He joined CERC in 1981 and has been involved in the Shore Protection Manual revision, numerical modeling of shallow-water waves, wave coherence, wave height distributions, remote sensing, image analysis, and instructing in workshops and the Coastal Engineering Short Course. He received a B.S. degree in aerospace engineering (1972) from Iowa State University of Science and Technology, an M.S. degree in coastal and oceanographic engineering (1978), and a Ph. D. degree in civil engineering (1981) from the University of Florida.

STEPHEN CURTIS KNOWLES

Mr. Knowles is a physical scientist in the Coastal Processes Branch, Research Division, Coastal Engineering Research Center (CERC). He has been working within the Barrier Island Sedimentation Study work unit at CERC since April 1984. Mr. Knowles received his B.S. degree in geology from Northern Arizona University, Flagstaff, in 1979 *and was awarded the M.S. degree in geology from the University of South Florida, Tampa, in 1983. Research interests include effects of coastal storms and sea level fluctuations upon coastal processes and geomorphic development, statistical analysis of shoreline position change, and analysis of sediment source and dispersal patterns. He is a member of the American Association of Petroleum Geologists.*

NICHOLAS C. KRAUS

Dr. Kraus is a research physical scientist in the Coastal Processes Branch, Research Division, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station. He joined CERC in September 1984 and is presently involved with numerical modeling of beach evolution, fundamentals of sand transport, including windblown sand, and finite amplitude wave theory. Previously he was a senior research engineer at the Nearshore Environment Research Center in Tokyo, Japan. Dr. Kraus received a B.S. degree in physics from the State University of New York at Stony Brook and a Ph. D. degree in physics from the University of Minnesota.

ROBERT C. LEE

COL Lee is Commander and Director of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. Prior to joining WES in August 1984, he was New Orleans District Engineer. He holds a B.S. degree in mechanical engineering and an M.S. degree in industrial engineering from Northeastern University. He is also a graduate of the US Army Command and General Staff College, the US Army War College, and the Executive Development Program, Whittermore School of Business and Economics, University of New Hampshire.

JOHN H. LOCKHART, JR.

Mr. Lockhart is a civil engineer in the Hydraulics Design Branch of the Hydraulics and Hydrology Division (H&H), Directorate of Civil Works, Office, Chief of Engineers (OCE), US Army Corps of Engineers, Washington, DC. He started his career as a hydraulic engineer with the US Army Engineer District, Fort Worth, Texas, in 1960. He transferred to the US Army Engineer District, Jacksonville, Florida, in 1965, and moved to the US Army Engineer Division, South Atlantic, where he served in the H&H Section and later in the Plan Formulation Branch specializing in coastal projects. He moved to

OCE in 1979 as the coastal specialist in the H&H Branch/Division. Mr. Lockhart holds a 1960 B.S. degree in petroleum engineering from Texas Technological University and a 1972 M.S. degree from Georgia Institute of Technology. He has authored three publications, co-authored two papers, and received three awards. He is a registered professional engineer and a member of NSPE, ASCE, ASBPA, and the Coastal Society.

PAUL F. MAY

Mr. May is a research physical scientist at the US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center (CERC), Engineering Development Division, Coastal Structures and Evaluation Branch. He is the Principal Investigator on the Coastal Engineering Information Management System Program and is a technical advisor for the joint-agency (CERC/National Ocean Service (NOS) Shoreline Movement Studies). Before joining the CERC staff, Mr. May worked as a researcher at the Department of Environmental Sciences, University of Virginia, and as a geologic consultant with Coastal Research Associates. He received his degree in geology from Ball State University in Indiana and is registered as a professional geologist.

SUZETTE KIMBALL MAY

Dr. May is a research physical scientist in the Coastal Processes Branch, Research Division, Coastal Engineering Research Center (CERC). She has been the principal investigator for the Barrier Island Sedimentation Study work unit since she joined CERC in December 1983. Research interests include geomorphic response to high intensity, short-term events, nearshore profile variations, nearshore sediment sorting, and the effects of variations in static water levels. Dr. May completed the requirements for a B.S. degree in geology in 1974 at the College of William and Mary, received an M.S. degree in geophysics from Ball State University, and a Ph. D. degree in coastal geomorphology from the University of Virginia in 1983. She is a registered professional geologist in the State of Virginia and is a member of the American Geophysical Union, Geological Society of America, Society of Economic Paleontologists and Mineralogists, the American Society of Limnologists and Oceanographers, the American Shore and Beach Preservation Society, and Sigma Xi.

WILLIAM F. McCLEESE

Mr. McCleese is program manager for the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program at the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. Appointed to this position in April 1984, McCleese has overall responsibility for planning, coordination, and execution of the program. McCleese is a 13-year veteran of the WES Office of Technical Programs and Plans where he provided staff guidance to officials of the five WES laboratories in planning, developing, programming, analyzing, and reviewing their work loads. He was responsible for formulating and disseminating substantive policies and procedures to govern the WES research program. Prior to that assignment, he was a research civil engineer for 4 years in the Concrete Division at WES. He received his B.S. degree in civil engineering from the University of Cincinnati.

WILLIAM R. MURDEN, JR.

Mr. Murden is chief of the Dredging Division, US Army Corps of Engineers Water Resources Support Center, a component of the Directorate of Civil Works. Prior to moving to Washington, he was an engineer with the Norfolk District where he was involved in the construction and operation of the J. H. Kerr and Philpott multiple-purpose hydroelectric projects and in the dredging program. He attended the Citadel prior to serving as a command pilot during World War II. Later he attended Elizabethtown College in Pennsylvania, where he received a degree in mechanical engineering, and Heed University in Florida, where he earned the M.B.A. degree. Mr. Murden has been chairman of the Corps of Engineers Marine Engineering Board for the past 12 years. He is a registered professional engineer in the District of Columbia and Louisiana; chairman of the Corps of Engineers Committee on Dredging Technology; honorary chairman of the Board of Directors of the World Organization of Dredging Associations; honorary chairman of the Board of Directors of the Western Dredging Association; and chairman of the Finance Committee of the Permanent International Association of Navigation Congresses. Mr. Murden also belongs to the National Academy of Engineering, the American Society of Mechanical Engineers, the Society of American Military Engineers, and the Society of Naval Architects and Marine Engineers.

JOAN POPE

Ms. Pope is a research physical scientist in the Coastal Structures and Evaluation Branch, Coastal Engineering Research Center (CERC). Prior to her transfer to CERC in 1983, she worked in the US Army Engineer District, Buffalo (NCB). She began work with NCB in 1974 as a geologist in the Foundations and Materials Branch and in 1977 was reassigned to the Coastal Engineering Section. Her experiences include coastal processes evaluation, coastal structure design, plan formulation, project monitoring, inspection and evaluation, geomorphic studies, remote sensing, and navigation project planning and design. She received a B.S. degree from the State University of New York at Oneonta and an M.S. in geology from the University of Rhode Island. Ms. Pope is a member of the Society of Economic Paleontologists and Mineralogists and is a registered professional geologist in the State of Indiana.

WILLIAM E. ROPER

Dr. Roper is the assistant director of Research and Development (R&D), Office, Chief of Engineers (OCE). He has headed the Corps' Civil Works R&D program at OCE since 1981. Prior to joining the Corps, he was director of Plans and Programs and chief of the Surface Transportation Regulatory Programs for the Environmental Protection Agency in Washington, DC. Dr. Roper received the B.S. and M.S. degrees in mechanical engineering at the University of Wisconsin. He then earned a Ph. D. degree at Michigan State University, specializing in environmental engineering. He is a registered professional engineer in the State of Wisconsin.

ALEX SHWAIKO

Mr. Shwaiko has served as chief of the Office of Policy, Civil Works Directorate, Office, Chief of Engineers (OCE), since 1980. Previous to that time, he served for a year as a senior engineer at the US Army Research and Development Laboratory at Fort Belvoir and 18 years in the Planning Division, Civil Works, where he rose to the position of chief. He received a B.S. degree in civil engineering at the University of Wisconsin and did graduate work at Georgia Tech. He is a member of the Senior Executive Service.

CECIL W. SOILEAU

Mr. Soileau graduated from the University of Southwestern Louisiana at Lafayette in August 1961 with a B.S. degree in civil engineering. He was briefly employed with the Louisiana Department of Transportation and Development as a surveyor and highway construction inspector, Professional Engineer Grade I, before enlisting in the US Army in February 1962. He joined the New Orleans District as an engineer trainee in September 1962 and trained in all the technical Divisions before being permanently assigned to the Coastal Engineering Section, Engineering Division, in April 1963, as a hydraulic engineer. In May 1967 he became chief of the Hydrologic Engineering Section and later served as chief of the Coastal Engineering Section and the Hydraulic Design Section in the Hydraulics and Hydrologic Branch. In June 1981 he became chief of the Hydraulics and Hydrologic Branch where he has served since then. In 1980 and 1982 he participated in fact-finding studies in the Peoples Republic of China and Suriname, respectively. Mr. Soileau is a member of numerous professional societies and organizations, and he is a registered professional engineer and land surveyor in the State of Louisiana.

BORY STEINBERG

Dr. Steinberg has been chief of the Programs Division, Civil Works Directorate (CWD), Office, Chief of Engineers (OCE), Department of the Army, since 1980. He served in the US Army during the following years: 1956-1958 and 1961-1962. He has had various assignments in the Construction and Engineering Division, New York District. He has also had several assignments of increasing responsibility in the Programs Division, CWD, OCE (1968-1974), including assistant chief of the Division (1974-1979). He was chief of the Planning and Coordination Office, Near East Project Office, US Army Corps of Engineers (Israeli Airbase Project) from 1979-1980. He earned the M.S. degree in public financial managing and budgeting from George Washington University in 1973 and the D.P.A. degree in public administration from George Washington University in 1984.

C. LINWOOD VINCENT

Dr. Vincent is a research physical scientist at the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), Research Division, and he recently became technical manager of the Wave Information Study (WIS). Dr. Vincent joined the Wave Dynamics Division, WES, in 1974 and participated in the *original development of WIS. He was chief, Coastal Branch, Wave Dynamics Division, from 1975-1978. At Fort Belvoir, Virginia, he was chief, Coastal Oceanography Branch, CERC, from 1978-1983 and was instrumental in the development of CERC's shallow-water spectral wave model capabilities. From 1983-1985, Dr. Vincent worked as a consultant with Offshore and Coastal Technologies, Inc., to develop a hurricane wave model used in reanalysis of the hurricane climatology in the Gulf of Mexico for several oil companies. Dr. Vincent is a member of Phi Beta Kappa and is a 1978 recipient of the US Army Research and Development Award and the 1984 recipient of the ASCE Walter Huber Research Prize.*

WILLIAM L. WOOD

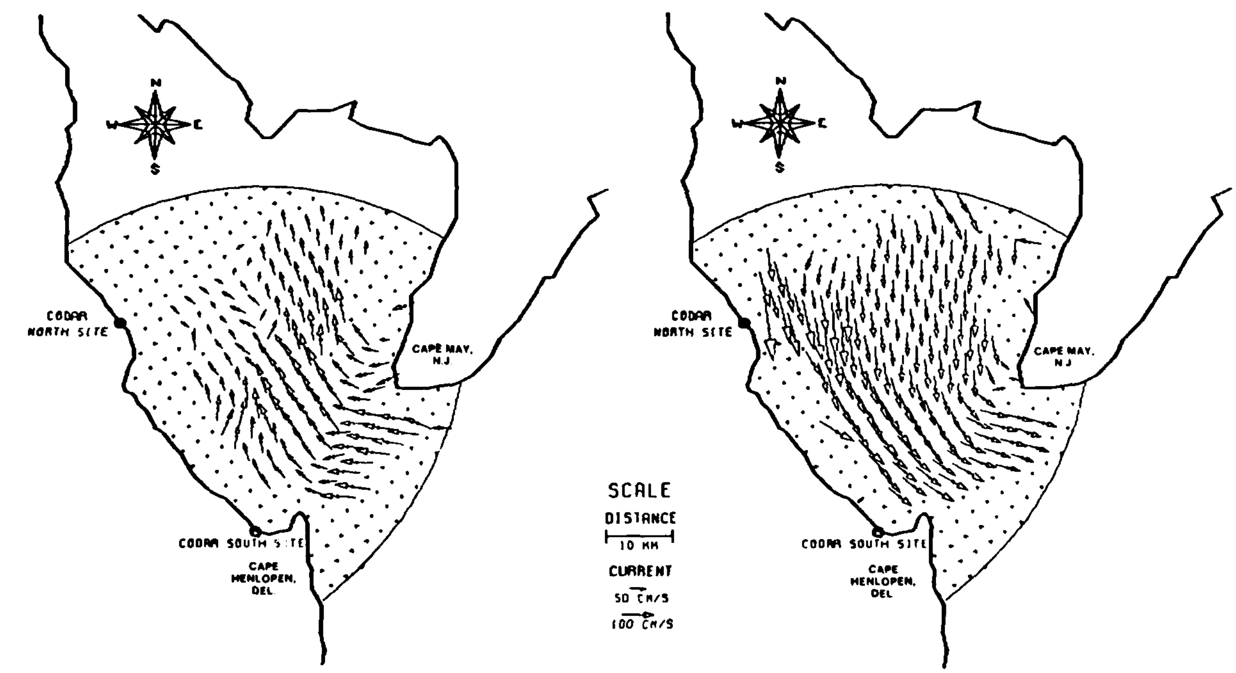
Dr. Wood is chief of the Engineering Development Division, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES), a position held since July 1984. He received a B.S. degree in applied mathematics and physics from Michigan State University in 1963. Dr. Wood completed his Ph. D. in geophysical fluid dynamics at Michigan State University through the CIC Distinguished Traveling Scholar program at the University of Chicago. He joined the faculty of the Natural Science Department, Michigan State University, in 1969. In 1972, Dr. Wood became an associate professor in the Department of Geosciences, Purdue University, and in 1975 was named Director of the Great Lakes Coastal Research Laboratory at Purdue. He was also named Director of the Hydromechanics Laboratory, Department of Civil Engineering, Purdue University, in 1982. Dr. Wood is a member of several professional and learned societies including: Sigma Xi, Sigma Gamma Epsilon, American Meteorological Society, American Geophysical Union, International Association for Great Lakes Research, and the American Association for the Advancement of Science.

APPENDIX A

REMOTE SENSING EXPERIMENT: COASTAL OCEAN DYNAMICS APPLICATIONS RADAR (CODAR)

CODAR, a shore-based, high-frequency, coastal radar, recently completed its initial field demonstration. The project, a major milestone in the CERC remote sensing program, was a joint effort with NOAA to monitor surface currents in the lower Delaware Bay. The primary objectives were to demonstrate the operational utility and accuracy of CODAR for monitoring both the spatial and temporal variability of surface currents and to provide training for CERC personnel responsible for subsequent field demonstrations.

CODAR makes use of the Bragg scattering mechanism and the subsequent Doppler frequency shift to measure radial, surface current velocities. For the Delaware Bay experiment, two radar sites were established approximately 28 km apart on the western shore of the bay (Figure A1). The use of two systems provided an overlap, or common coverage, over most of the lower bay. This area was then overlaid with a 2- by 2-km grid. Radial velocities measured from each radar site that fall within a user-specified area around each



a. Total current vector map showing period of flood tidal flow, 16 October 1984, 10:20 a.m.

b. Total current vector map showing period of ebb tidal flow, 15 October 1984, 5:05 p.m.

FIGURE A1. TWO RADAR SITES USED TO RECORD SURFACE CIRCULATION IN DELAWARE BAY (velocity threshold, 5 cm/sec; grid spacing, 2 by 2 km; area resolution, 3-km radius) grid point are combined, using a least squares method, to give the resultant, or total, current velocity. If, as a result of insufficient signal strength, less than two radial vectors reside in the prescribed resolution area, the problem is underdetermined, and the result is a data gap at that grid point location. Radial velocities were recorded at each site every 90 min and later combined to produce hardcopy, total vector maps at 45-min intervals (Figure A1). Fine resolution current maps such as these are virtually impossible to produce using conventional methods. CODAR also provides information on the uncertainty of each current vector. There is a tendency for higher uncertainty in vectors very close to a shoreline.

In addition to surface currents measured from sea scatter, high-frequency (HF) drifter/transponders were deployed to provide direct, Lagrangian measurements of surface drift for comparison with CODAR sea echo measurements. The transponders, when interrogated, actively retransmit the 25.4-MHz signal rather than simply reflect it. This provides greater range and allows up to 128 transponders to be individually interrogated. CODAR has the unique ability to track the velocity and position of the drifters while normal surface current measurements are in progress. Three transponders were released and tracked for a period of 1 week (Figure A2). Radial velocity and range were recorded at each site every 90 min. Combination of the data from the two sites yielded the total velocity and position of the drifter. All three were successfully recovered after the experiment.

Concurrently, NOAA, as part of an 18-month general circulation study of the Delaware River and Bay, had deployed various in situ current sensors within the CODAR coverage area. These included a bottom-mounted, acoustic, Doppler current profiler and several other meters moored at various depths. By assuming that the tidal component of circulation differs little from the surface to some 10 m, comparisons of tidal current coefficients obtained by CODAR and these current meters can be made.

The experiment lasted approximately 5 weeks. Preliminary results indicate a highly successful demonstration, with significant amounts of sea echo and transponder data currently undergoing analysis. In addition to providing surface current patterns in the region of interest, information extracted from such studies can be used in numerical model verification.

AD-A159 991 PROCEEDINGS OF THE MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD (43R..(U) COASTAL ENGINEERING RESEARCH CENTER VICKSBURG MS R W WHALIN AUG 85 5/6

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MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

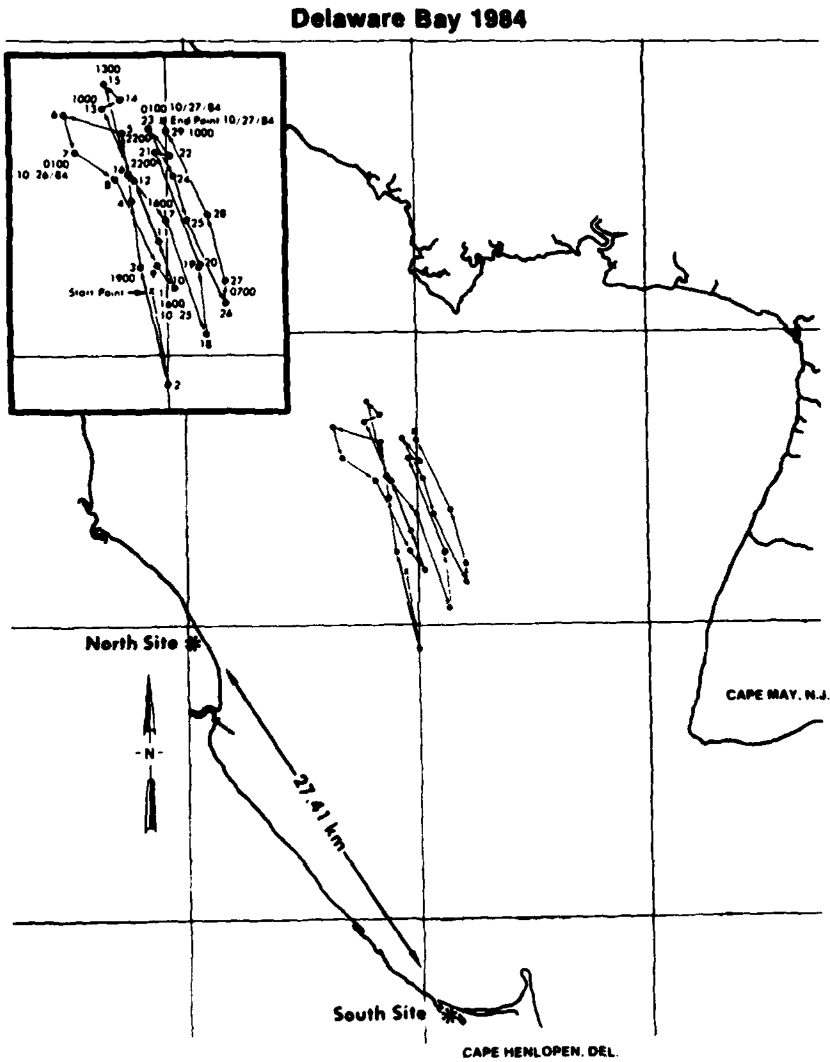

FIGURE A2. DRIFTER/TRANSPONDER TRAJECTORY FOR 2-DAY PERIOD (beginning 4:00 p.m., 25 October)

APPENDIX B

LETTER FROM OFFICE OF MANAGEMENT AND BUDGET TO ASSISTANT SECRETARY OF THE ARMY FOR CIVIL WORKS

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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

OCT 5 1983

Honorable William R. Gianelli
Assistant Secretary of the Army
for Civil Works
Room 2E570 - Pentagon
Washington, D.C. 20301

Dear Bill:

We have completed our E.O. 12322 reviews of the Olcott Harbor, New York, Charlotte County, Florida, and Presque Isle Peninsula, Erie, Pennsylvania. Your incoming letters were dated April 11, 1983; June 22, 1983; and June 10, 1983, respectively.

The benefits of these projects are primarily recreational. This Administration is not opposed to providing incidental recreation at projects built for other purposes. Federal water projects designed primarily to provide recreational opportunities, however, are inconsistent with this Administration's budget priorities, and are not in agreement with the Administration's policy to rely on the private sector to provide public services whenever possible.

Accordingly, we cannot support authorization of these projects for construction by the Federal Government.

Sincerely,

Frederick N. Khedouri
Associate Director
for Natural Resources,
Energy and Science

APPENDIX C

SUMMARY OF "DUCK '86" EXPERIMENTS

ACCORDING TO GROUP

EXPERIMENTS PROPOSED BY CERC PERSONNEL (rev. 3/29/85) DUCK '86

(experiment area)	(area manager)
I. Waves & Wind	Dr. Steven Hughes
II. Currents	Dr. Jon Hubertz
III. Sediment Transport	Dr. Lee Weishar
IV. Geomorphologic Change	Dr. Suzette May
V. Data Management	Mr. William Birkemeier

I. WAVES & WIND

(I-1) [Core Exp't]
Experiment: Directional wave spectra in intermediate depth water.
PI's : Miller, FRF Staff
Equipment : Pressure and other types of wave gages
Time : Duration of Duck '86

(I-2) [Core Exp't]
Experiment: Wide-area wave & current parameters (out to 40 km from pier)
PI's : Driver, Hubertz
Method : Directional wave spectra, as well as surface currents, measured using CODAR
Equipment : CODAR, van
Time : CODAR can operate for experiment duration

(I-3) [Core Exp't]
Experiment: Time series of water surface elevation across the nearshore zone ('photo-pole' experiment)
PI's : Hughes, Kraus, Ebersole, Earickson
Method : Simultaneous filming of the time history of the water surface elevation at steel pipes installed across the nearshore zone
Equipment : Movie cameras, steel pipes (approx. 50), scaffolding
Time : Approx. 1 to 2 hr of operation for different wave conditions 3 - 5 days. (Will try to provide near-shore wave info support for other experiments)

(I-4)
Experiment: Improvement of practical methodology for coastal field data collection
PI's : Pope, Szuwalski
Method : Comparison of standard and proposed methods for obtaining the local incident wave height, period and direction
Equipment : (Would like to coordinate with other experiments in which local wave data are being obtained)
Time : 10 days

(I-5)	[Core Exp't]
Experiment:	Nearshore atmospheric mass and momentum fields in storms
PI's :	Long, Miller, Hubertz
Method :	Monitor atmospheric variables
Equipment :	Meteorological tower housing vertical array of anemometers; thermometers, humidiometers
Time :	1 - 2 weeks or perhaps longer, depending on needs of nearshore current and wave experiments

II. CURRENTS

(II-1) [Core Exp't]
Experiment: Measure time-meam currents in the nearshore area
PI's : Hubertz, Crawford
Method : Mount 6 current meters with pressure gages on pilings on a cross-shore line; will coordinate with Expts. I-1 and I-5.
Equipment : Marsh-McBirney EM current meters
Time : Approx 30 days

(II-2)
Experiment: Wide-area current & wave parameters (out to 40 km from pier)
PI's : Driver, Hubertz
Method : Directional spectra and surface currents will be measured using CODAR
Equipment : CODAR, van
Time : CODAR can operate for experiment duration

(II-3)
Experiment: Improvement of practical methodology for coastal field data collection
PI's : Pope, Szuwalski
Method : Comparison of standard and proposed methods for obtaining the local longshore current speed
Equipment : Floats, dye packs, etc. (Would like to coordinate with other experiments in which local current data are being obtained.)
Time : 10 days

(II-4)
Experiment: Distribution of longshore and cross-shore current across the surf zone
PI's : Kraus, Vemulakonda
Method : Measure current in conjunction with Expt. III-1 on a line across the surf zone
Equipment : 5 - 7 two-component electromagnetic current meters
Time : 1 - 2 weeks, depending on Expt. III-1

III. SEDIMENT TRANSPORT

(III-1) [Core Exp't]
Experiment: Distributions of longshore & cross-shore sediment transport rates across the surf zone (under low to medium wave energy)
PI's : Kraus, Walton, Vemulakonda, Wood
Method : Diver-operated sediment traps in surf zone and swash zone. Simultaneous measurement of longshore current & breaking wave height; local wave directional spectrum, if possible. May also deploy electronic instrumentation for sediment movement and concentration.
Equipment : Sediment traps and weighing equipment; 3 - 5 current meters; photo-pole equipment (Expt. I-3).
Time : 5 - 7 days

(III-2)
Experiment: Comparison of sediment characteristics between trapped and ambient sand in Expt. III-1
PI's : Hands, Hansen
Method : Analysis of samples

(III-3) [Core Exp't]
Experiment: Onshore-offshore sediment transport outside the surf zone
PI's : Weishar; Wright, Sallenger
Method : Measure onshore-offshore movement (mass transport and sediment transport) outside the surf zone at various depths on a line normal to the shoreline. Two tripods will be used to mount instruments. In addition, a series of approx. 8 sand tracer experiments will be carried out to measure rates of bed load transport.
Equipment : Two tripods, each containing 1 Sea Data 635-12 gage and 1 OBS suspended sediment sensor; one tripod will have an RD acoustic profiling gage.
Time : 3 - 3 1/2 weeks on site; tracer expt's require 8 - 10 days

(III-4)
Experiment: Tracing of sediment movement in offshore region by means of 'Sea Daisies' (and evaluation of Sea Daisies)
PI's : Hands, Hansen
Method : Track movement of almost-neutrally buoyant markers on the sea bottom in an area near to tracer used in Expt. III-3

IV. Geomorphologic Change

(IV-1) [Core Exp't]

Experiment: Profiles for geomorphological development and response, including intensive and dense pre- and post storm surveys

PI's : Birkemeier, Mason

Method : Profiling with CRAB

(IV-2) [Core Exp't]

Experiment: Sediment sorting processes across the nearshore zone

PI's : May; Richmond

Method : Take short cores, together with measurement of current, on a grid

Equipment : Remotely operated sampler mounted on sled or CRAB

(IV-3) [Core Exp't]

Experiment: Structure of rapidly developing morphology (in storm events)

PI's : May; Richmond

Method : High resolution profiles (temporal); short cores

Equipment : CRAB/sled with remotely operated core drivers

(IV-4)

Experiment: Exchange of sediment between foreshore and surfzone

PI's : Howd

Method : High-accuracy profiling; metal survey rods

Equipment : CRAB; Zeiss survey equipment; metal rods

(IV-5)

Experiment: Foreshore response over a tidal cycle

PI's : Howd

Method : Similar to IV-4, but rod surveys conducted much more frequently, at approx. 45-min intervals for 12 hr

Equipment : See IV-4

APPENDIX D
RECOMMENDATION LETTERS
FROM CERB MEMBERS

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION, CORPS OF ENGINEERS
P.O. BOX 2870
PORTLAND, OREGON 97208-2870

REPLY TO
ATTENTION OF:

June 10, 1985

Technical Engineering Branch

BG C. E. Edgar III
President, Coastal Engineering Research Board
U.S. Army Corps of Engineers
20 Massachusetts Avenue, NW
Washington, DC 20314-1000

Dear General Edgar:

This is a reply to the questions raised by the CERC on the future of coastal engineering within the Corps.

- SHOULD CORPS FUND MORE BASIC COASTAL ENGINEERING R&D?

There is no question that more basic Coastal Engineering R&D and coastal data collection is needed. It is also reasonably apparent that the maximum immediate returns on investment come in the development stage of R&D using previous basic research. In a system that is level funded, dollars are logically oriented to the development phase of the equation. The answer to the issue of basic research and field data collection therefore hinges on expanded funding of Coastal Engineering.

The expansion of funding can come from various resource areas. Assuming that user fee legislation will pass,the legislation can dedicate a percentage of those funds to field data collection and R&D, (if prudently written). Within our own present operations and maintenance budget there is also the possibility of greater funding by piggybacking R&D and data collection onto project funding, as there is a close tie between O&M and R&D. The coastal processes modeling effort is strongly associated with our challenges in sediment transport which effects our dredging, dredged material disposal, structural rehabilitation, and structure modification programs. To answer questions on sediment transport we must have basic information on wave induced, tidal induced, wind induced and density induced currents. Those currents must be reduced to their effects on sediment transport. Basic research on sediment transport is required to quantify those answers to an accuracy greater than an order of magnitude. We must also refine our data collection effort so that there is a basis for evaluating research efforts in sediment transport. The field data collection effort may partially duplicate activities associated with DMRP studies but must be developed so cause effect relationships are more definable than the order of magnitude answers obtained then. Wave, wind, and current data need to be collected, as does the dispersion and advection rates of sediments. Wave data and predictive capability of wave effects in navigation channels are also required if we and ports are to optimize navigation channel design and maintenance requirements. Normal dredging operations should be scrutinized for targets of opportunity for sediment tracing and monitoring of currents, winds, and waves. The General Investigations program also has unique needs for coastal data and research that are seldom satisfied with our present mode of doing business. Therefore, it should not be disqualified as another source of added funding.

The effect of not tapping those added funding resources will be a continuing decay of coastal engineering in the U.S. Our universities respond to the job markets available to them and if opportunities for research are not available in this field they will be driven to other endeavors. Likewise, it is assumed that the impressive staff of employees with Doctorate and Masters Degrees employed by the research center cannot be retained unless a reasonable amount of their work is in basic research as they have been trained in the publish or perish climate of acadamia. Without some base effort in research which will allow them to maintain their reputations, it is probable that they will seek employment elsewhere.

- SHOULD THE CORPS ESTABLISH A *NATIONAL* CENTER OF EXCELLENCE IN COASTAL/OCEAN ENGINEERING?

- IF SO, WHAT ADDITIONAL FACILITIES ARE REQUIRED?

- IF SO, WHAT ADDITIONAL OTHER RESOURCES ARE NEEDED?

The Corps is the national center of excellence in coastal engineering. The center is composed of the Coastal Engineering Research Center, HQUSACE and FOA's. There are opportunities to strengthen all elements of this center of excellence. At the CERC those opportunities revolve around equipping itself to do more basic research in wave spectra and sediment transport, conducting project studies with wave spectra, whether those studies involve shoreline processes or the development of damage coefficients for breakwaters, and development of low cost rapid methods of determining if a project is technically feasible.

The greatest need in maintaining or improving our position as a center of excellence, however, lies in staffing and training personnel in our District offices. Those offices are our first line of contact with Corps customers and should be staffed with the top coastal designers in the nation. A few of those top designers are in existence but in many cases the promising young coastal engineers divert to program management or some other field long before they could become top designers. The reason for this diversion to other areas is in part the lack of a development ladder for technically oriented people at District, Division or HQUSACE levels. At the District level to advance beyond a GS-12 requires that the employee become a manager of human resources. The normal working-level coastal engineer cannot rise above a GS-11. The system must be modified so there is a development ladder that allows the technically oriented to advance to levels equivalent to management grades. Further, coastal engineering is not recognized as a design specialty in many of our districts or, if it is recognized, it's a one man staff in a minor subsection. Considering the Corps' mission in flood control and navigation, and the percentage of those projects in the coastal arena, the lack of recognition seems impossible but nevertheless it exists and needs correction. There is also a growing tendency to centralize coastal engineering expertise at the Coastal Engineering Research Center. This centralization is stifling innovative problem solving, creating dissatisfaction at district level, and is driving the system to becoming a center of mediocre solutions.

Expanding the Corps' mission to ocean engineering means we are seeking a new role beyond our conventional mission of flood control and navigation. Insofar as that new role is a direct result of our knowledge of basic physical processes associated with coastal engineering, expansion into this arena may be warranted. Customers in ocean engineering are, however, normally associated with oil and mining interests and the priorities for use of our facilities and manpower should remain oriented toward flood control and navigation unless we are given a role in a much broader program.

- SHOULD CORPS UPDATE NATIONAL SHORELINE STUDY?

An update of the National Shoreline Study may be warranted in some regions of the nation but appears to have very limited value unless the underlying shoreline processes are understood. The study should, if undertaken nationally, be expanded to at least look at regional geology and possible causes of shoreline instability. The reasons for instability can be many, a change in sea level, a change in sediment source magnitude, recovery from mans interference, etc. A base understanding of the dominant processes involved would be a great asset in developing zoning and/or coastal protection.

- SHOULD CORPS BE THE FEDERAL ENGINEER FOR COASTAL/OCEAN ENGINEERING?

The Corps has the dominant Federal roll in coastal engineering and because of its mission in flood control and navigation should maintain that roll. The workshop planned in San Francisco this fall will enhance the image of the Corps in their role of working for others and other workshops, participation in ASCE, and international coastal engineering conferences should continue to emphasize that role.

- ARE ADDITIONAL STUDIES/DEMONSTRATION PROJECTS NEEDED FOR INNOVATIVE LONG-TERM RECURRING CE PROJECTS BEACH NOURISHMENT, COASTAL DREDGING?

Studies are needed to better understand the "fate" of dredged materials when disposed in various depths of water. These could take the form of demonstration projects, but would probably need to be regionalized. With the control of many of our rivers' freshet peaks with dams, one of the side effects has been a reduction of sediment transport potential to the coastline. This has created a sediment deficit along many of our shorelines and in the long term may have severe affects on shoreline processes. Properly placed dredged materials can help offset these deficits without materially affecting the environment. Proof of the beneficial affects of dredged material disposal are needed. Study of contaminated sediments is another area where demonstration projects would have value. There are also many other areas where innovative untried solutions could be installed as demonstration projects.

- SHOULD CERC FACILITIES (EXPANDED IF NECESSARY) SERVE AS A NATIONAL LABORATORY FOR COASTAL ENGINEERING R&D?

CERC facilities could serve as a national laboratory if not fully utilized for Corps studies. Priorities for use would have to be firmly established before a commitment was made in this direction. Considering the capital investment in spectra wave generators, wave tanks, and other equipment allowing outside use by others such as academia and NSF, would be a sound investment and could promote a great deal of basic research without a significant increase in costs.

We should, therefore, actively solicit closer ties with academia and industry. The facilities are ideal for graduate student thesis development, and with agreements with Universities, could be used as part of their graduate student programs or as student intern programs. CERC staff with the aid of CERB civilian board members should lay out a procedure and draft agreement which has been fully staffed through office of counsel and office of policy so we can assess the action required on this important area at our next meeting.

The ability to work for industry or the AE community needs to be integrated into our coastal program. This will take some innovative thinking to accomplish as we are both constrained by regulation and philosophy. The regulation type constraints can be overcome as we do have unique facilities and areas of expertise not commonly available to the private sector. The philosophical constraints which hamper us in risk taking I believe can also be overcome by a better understanding of risks. A "straw man" program needs to be assembled so we have a starting point to initiate action. The CERC should assemble the "straw man" with the aid of HQUSACE and FOA's. When it is assembled we can proceed with refinement of methods to undertake work for or with others.

o WHAT AREAS IN COASTAL ENGINEERING R&D SHOULD RECEIVE GREATER EMPHASIS?

The coastal data collection program should be greatly expanded. Wave data is required to optimize the use of existing navigation facilities, design new facilities, and allow assessment of innovative designs and repairs. The data collection program is closely associated with our costs of operations and maintenance in the dredging program, structural rehabilitation program, and assessment of coastal flooding. Clearly without a good data set that examines average and extreme conditions there is no possibility of doing fast track economic designs, or for that matter, making an assessment that a job is technically feasible. Delaying obtaining such baseline data until a project is in reconnaissance stage or feasibility stage of preparation will delay the project beyond the point that most potential customers will not find the Corps to be a viable partner in the construction or design of a project. With the advent of significant local contributions on projects, we must be able to tell the customer that the project is technically feasible, the life cycle cost of the project and the risks associated with the design during the early phases of study before he has a major financial involvement. Without baseline data on waves, general climatology, and in many instances sedimentation, that information cannot be supplied.

In the arena of basic research, our area of least reliability is sediment transport. The technical feasibility of many projects hinges on the relationships derived for sediment transport. At present the basic equations used for this type analysis gives us order of magnitude solutions and in many instances do not recognize major source areas for sedimentation. These deficiencies are partially offset by local knowledge, field studies, and other innovative procedures practiced at the district levels. Centralization of coastal engineering at CERC has curtailed abilities to reconcile model results with field reality and intensive efforts must be mounted to reconcile those order of magnitude errors in sedimentation.

- WHAT AREAS NOT COVERED IN COASTAL R&D SHOULD BE COVERED?

Basic research in sediment transport is an area that has received little attention and should be approached with a concentrated effort which may include moveable bed modeling, massive field data collection effort, and major changes in math modeling concepts. Other arenas of research seem to be covered but would certainly benefit from more intensive and expanded efforts.

- CAN CE EQUIPMENT (CRAB, FRF, LAB FACILITIES) BE BETTER USED AND/OR EXPANDED TO BE OF GREATER BENEFIT TO THE NATION?

Equipment development for measurements of phenomena are best left to industrial or academic sources. The testing of that equipment for Corps use certainly is an appropriate mission of the Corps.

- SHOULD CE, OTHER FEDERAL AGENCIES, NSF, AND ACADEMIA POOL RESOURCES TO INCREASE COASTAL ENGINEERING RESEARCH PRODUCTS? OR WILL THIS STIFLE RESEARCH PRODUCTIVITY?

Joint use of facilities should not stifle research productivity as long as the research being conducted is not controlled by an individual group. Centralizing decisions on research to be performed would, however, stifle creativity and is not recommended. Centralization of Corps research decisions with program monitors has resulted in a program almost totally dedicated to development of previous research. We must be progressive in our research efforts, whether basic or applied, if we are to remain a viable forward looking organization

Sincerely,

George

George R. Robertson
Brigadier General, U.S. Army
Division Engineer

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
630 Sansome Street, Room 720
San Francisco, California 94111-2206

REPLY TO
ATTENTION OF:

June 3, 1985

Office of the Division Engineer

SUBJECT: Coastal Engineering Research Center - Evolving Responsibilities and Leadership

Brigadier General C. E. Edgar III
Deputy Director of Civil Works
U.S. Army Corps of Engineers
20 Massachusetts Ave., N.W.
Washington, DC 20314-1000

Dear General Edgar:

This letter is in response to your request to CERB members at our recent meeting at WES that we provide our views on the questions posed by Dr. Bob Whalin about expanding Corps and CERC responsibilities and leadership in coastal engineering and allied fields.

Ten separate questions were presented on Dr. Whalin's viewgraphs; since they are rather overlapping, I have consolidated certain ones and added some general comments, as follows:

Questions 1 and 10. Should the Corps fund more basic coastal engineering R&D? Should the CE, other Federal agencies, NSF and academia pool resources to increase coastal engineering research products? Or will this stifle research productivity?

Answer. The overall answer is certainly affirmative, if it supports our basic Corps missions. However, several points and distinctions raised at the recent CERB meeting should be noted. The general shortage of funds for research and development is limiting and other sources, where appropriate, should be sought. As discussed, the use of project-oriented operations and maintenance, planning and/or construction funds may be possible. Three pertinent examples are now underway within SPD wherein Planning funds for the Coast of California Storm and Tidal Wave study, and O&M funds for both the Oceanside sand bypassing project and the Crescent City prototype dolos study are assisting

CERC in applications-oriented coastal research. The planned Coastal Remote Sensing study will, we hope, soon constitute a fourth example. In keeping with these examples, a primary focus of CERC R&D activities should be support to the field.

We also generally concur with Professor Wiegel's view that laboratories such as CERC are best at sustained applications research, while academia is well suited for basic research. Corps support for basic research at universities and in cooperation with the National Science Foundation and other agencies, as appropriate, should therefore be considered as a adjunct to CERC activities. It would appear reasonable, therefore, that a slice of our annual funding be directed to basic research, whenever possible.

Funding for both solicited and unsolicited proposals, is desirable; although, if by the Corps alone, it could currently be only at a token level, due to limited resources. It may be possible to form a cost-sharing consortium to implement studies of mutual interest. Also, pooled funding need not stifle innovation, if properly structured.

Questions 2, 6 and 9. Should the Corps establish a national center of excellence in coastal/ocean engineering? If so, what additional facilities and other resources are required? Should CERC facilities serve as a national laboratory for coastal engineering R&D? Can CE equipment (CRAB, FRF, lab facilities) be better used and/or expanded to be of greater benefit to the nation?

Answer. We believe that CERC, with its revitalized capabilities following its colocation with WES, is already the de facto national center for coastal engineering excellence; that it should be appropriately expanded; and that existing and future facilities could be used by an increasingly diverse group of users. However, we do not support formal designation of CERC, at this time, as a national center due in part to the legitimate interests of other agencies in their coastal mission. CERC should continue, consistent with administration funding goals, to emphasize expansion of R&D support to CE field offices and secondarily in response to the needs of other users. Still, as indicated above, it is desirable to improve services to an increasing group of other users and CERC should therefore improve its efforts to make its facilities and expertise available to others on a cost-reimbursable basis - including the FRF, laboratory equipment, modeling techniques and its increasing skills in remote sensing activities.

The question also suggests a possible deep ocean mission. CERC expansion into this subject area would involve significant overlap with other Federal agencies, including NOAA and the Navy. Facilities to conduct ocean engineering research are not presently required to support the CE civil works mission, (An expansion of the CE mission into the deep ocean is beyond the scope of this discussion.)

Question 5. Are additional studies/demonstration projects needed for innovative long-term recurring CE projects (Beach nourishment, coastal dredging)?

Answer. This Division fully supports the general concept of studies and demonstrations which reduce O&M costs: as indicated by my previous citation of the CCSTWS, Oceanside Sand Bypassing, the Crescent City prototype dolos study and the Coastal Remote Sensing demonstration. There is, however, legitimate question as to whether a significant number of additional studies present should be undertaken or whether more funds should be applied to studies currently underway. Based on current funding constraints and a need to develop useful applications, I incline toward the latter opinion. Nevertheless, there is much to be said for the pursuit of new ideas - not only to reduce recurring costs but also first costs. For example, office studies leading to prototype testing of imaginative alternatives to conventional design solutions - such as our very-expensive rubblemound breakwater structures - could be considered.

Questions 8 and 9. What areas in coastal engineering R&D should receive greater emphasis? What areas not covered in coastal R&D should be covered?

We plan to address this at some length at the next CERB meeting in presentation of our Division's research and related data-gathering needs. General subjects of concerns include wave data and use, including spectral information; coastal processes, beach nourishment, and rapid response shoreline surveys; structures, improved armor units and stability; and navigation simulation, including small boat harbor entrance navigation.

Question 3. Should the Corps update the National Shoreline Study?

Answer. Updating the National Shoreline study is probably not necessary due to the voluminous amounts of similar inventory material collected in the interim by the states as part of their individual Coastal Zone Management programs. In any case, Corps-sponsored coastal inventories, like the National Shoreline Study, should not generally be undertaken without a careful definition of need. There may be a ~~n~~ possible relationship here with ongoing Corps regional coastal processes-data collection programs such as the CCSTW and the Coast of Florida study; and this work could perhaps be expanded nationally, subject again to funding requirements and the need to adequately deal with present commitments.

Question 4. Should the CE be the Federal Engineer for Coastal/Ocean Engineering?

Answer. As hinted at my earlier answer to Question 2 regarding the status of CERC as a center of excellence, and based on pertinent legislation and directives, the Corps is in certain respects the de facto Federal Engineer for Coastal Engineering, although not for Ocean Engineering. Other agencies to be sure, have their own coastal engineering mission which they can handle themselves or turn to the Corps for assistance, as they may choose. I believe that this present situation is satisfactory and that formal designation is not required. An expanding role in performing work for others - i.e. the de facto role as the Federal Engineer - is something that will grow naturally from the recognized strength of the Corps in the field of coastal engineering. This strength, of course, must encompass all coastal elements of the Corps: USACE, CERC, coastal divisions and districts. In this regard, here in South Pacific Division we have recently been enlarging our long-established relationship with the Navy with added dredging and beach nourishment projects for that agency; and we hope that we can provide additional and improved services to the Navy and others in the future.

I do wish to offer one additional rather general comment, and this applies not only to CERC but to WES as a whole. I was impressed not only with the upgrading of facilities but with the outstanding qualifications of the staff in both their job-related and academic achievements. These achievements are even more remarkable when we recognize that they have been accomplished in an area which is somewhat isolated, although that isolation has diminished in recent years with improved transportation, from major population centers, with their various industrial, business and academic institutions which normally assist in the development of great research and experimental laboratories.

With this in mind, I believe that it would be greatly to WES's and particularly CERC's advantage to strengthen existing ties and create new ones with academic institutions; and specifically, to encourage employees to pursue advanced degrees in the immediate geographic area. This could be accomplished by creation of an independent university (a long-term proposition of especial interest to local interests and largely outside of the Federal and perhaps even government purview) or a working relationship with a major university with established technical programs in coastal engineering and other disciplines, which could result in a physical presence in the Vicksburg area and which could grant advanced degrees.

This is obviously only a preliminary thought, and does not imply criticism of existing links between WES-CERC, academia, and other institutions. But this suggestion is called to mind by the many other examples where close geographic proximity of laboratories, academic institutions and other private and government research facilities work to the advantage of all.

In closing, I appreciate this opportunity to comment on these concerns and hope that they will be helpful. Because of your need for a quick response some of the answers have been abbreviated. I look forward to further discussions at the forthcoming fall CERB meeting here in the Bay area.

Sincerely,

Donald J. Palladino
Brigadier General, U.S. Army
Division Engineer

UNIVERSITY OF CALIFORNIA, BERKELEY

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HYDRAULIC AND COASTAL ENGINEERING

10 June 1985

BG C.E. Edgar III
President, Coastal Engineering Research Board
Deputy Director of Civil Works
U.S. Army Corps of Engineers
(DAEN-CWZ-A), Room 7231
Washington, D.C. 20314

Dear Ernie:

This is in response to your request at the end of the 43rd CERB meeting to respond to the questions for the future posed by Robert Whalin.

Q1: SHOULD CORPS FUND MORE BASIC COASTAL ENGINEERING R&D?

A: Yes. In many ways it is better (both quality and cost) for the Corps to fund basic research in academic institutions. The development phases of research are probably done better in organizations such as CERC than in academic institutions. I suggest you ask Dean M. P. O'Brien for his opinion on this subject as he has given much thought to it recently.

Q2: SHOULD THE CORPS ESTABLISH A NATIONAL CENTER OF EXCELLENCE IN COASTAL/OCEAN ENGINEERING?

- IF SO, WHAT ADDITIONAL FACILITIES ARE REQUIRED?

- IF SO, WHAT ADDITIONAL OTHER RESOURCES ARE NEEDED?

A: Yes. I know of no other government agency that is as well suited for this. Must concentrate on use of the new directional spectra wave generator. New resources should be concentrated on field studies, and the instruments required to perform these studies.

DEPARTMENT OF CIVIL ENGINEERING • 412 O'BRIEN HALL • UNIVERSITY OF CALIFORNIA • BERKELEY, CALIFORNIA 94720
TELEX/TWX 9103667114 UC BERK BERK

Richard A. Denton 415/642-9028
James A. Harder 415/642-6776
Rodney J. Sobey 415/642-3162
Robert L. Wiegel 415/642-7340
J.W. Johnson (Emeritus) 415/642-7341
David K. Todd (Emeritus) 415/642-7341

Q2: SHOULD CORPS UPDATE NATIONAL SHORELINE STUDY?

A: It appears that this is presently being done for two regions in the California and Florida studies. An effort should be made at the present time to get existing data on other regions on a computer based information system using the techniques being developed as a part of the above mentioned studies.

Q4: WHAT AREAS NOT COVERED IN COASTAL R&D SHOULD BE COVERED?

A: There is insufficient work being done on the effect on beaches of sloped rip-rap sea walls and concrete cribs (such as at one portion of the San Francisco, CA, Ocean Beach) which are exposed to wave action only every few years when there is a combination of high tides and storm waves. Additional work should be done on perched beaches.

Q5: SHOULD CORPS BE THE FEDERAL ENGINEER FOR COASTAL/OCEAN ENGINEERING?

A: Yes, for coastal engineering. See previous comment that there does not appear to be any other Federal Agency as well suited for coastal engineering as the Corps. Other agencies might be suited better for ocean engineering.

Q6: ARE ADDITIONAL STUDIES/DEMONSTRATION PROJECTS NEEDED FOR INNNOVATIVE LONG-TERM RECURRING CE PROJECTS (BEACH NOURISHMENT, COASTAL DREDGING)?

A: I believe that the concept of a nearshore liner mound of dredged sand from a harbor maintenance job should be tried, of the type suggested at the 43rd CERB meeting. Also a perched beach should be tried.

Q7: SHOULD CERC FACILITIES (EXPANDED IF NECESSARY) SERVE AS A NATIONAL LABORATORY FOR COASTAL ENGINEERING R&D?

A: Not at the expense of facilities at academic institutions which are mostly in rather poor shape at the present time. I think that it is more important, from the standpoint of long range policy, to bring the facilities in academic institutions up to world-wide standards. For background information on this, please refer to the publication cited below.

<ins>Natural Hazards and Research needs in coastal Engineering</ins>, prepared for NSF and ONR by an Ad Hoc Committee for the Civil and Environmental Engineering Division of NSF, November 1984, 62 pp. John H. Nath and Robert G. Dean, editors.

Q8: WHAT AREAS IN COASTAL ENGINEERING R&D SHOULD RECIEVE GREATER EMPHASIS?

A: See answers to Q4 and Q6 above.

Q9: CAN CE EQUIPMENT (CRAB, FRF, LAB FACILITIES) BE BETTER USED AND/OR EXPANDED TO BE OF GREATER BENEFIT TO THE NATION?

A: I was impressed with the use of FRF in the ARSLOE experiment. I believe that the beach and nearshore studies being planned for FRF will also be of great benefit to the nation. The broadest possible use by many researchers of the directional spectra wave generator at CERC should be encouraged.

Q10: SHOULD CE, OTHER FEDERAL AGENCIES, NSF, AND ACADEMIA POOL RESOURCES TO INCREASE COASTAL ENGINEERING RESEARCH PROEUCTS? OR WILL THIS STIFLE RESEARCH PRODUCTIVITY?

A: I think that most basic research is done better in academia, and most developmental research is done better in professional laboratories such as CERC. Both are needed. I recommend that a policy be developed on how the overal research should be divided into these two categories.

Sincerely yours,

Bob

Robert L. Wiegel
Former Member, CERB

RLW:ke

cc: Dr. Robert Whalin

UNIVERSITY OF Miami

29 May 1985

Brigadier General C.E. Edgar III
Deputy Director for Civil Works
President, Coastal Engineering Research Board
Office of the Chief of Engineers
DAEN-CWZ-A, Room 7231
Department of the Army, Corps of Engineers
Washington, D.C. 20314

Dear General Edgar:

Rather than discussing the program of research point by point, I would rather address, in response to the questions raised by Dr. R. Whalin, the more general issue of future goals and orientation of CERC.

Indeed the general impression gained during our last meeting was that CERC has now reached its full momentum, the personnel is at work and performing well, the facilities are built or planned. This has been achieved in a much shorter time than I thought it would be possible. One should now expect quality research products to fulfill the research needs of the Corps. Where do we go from here on?

In view of the little support given to coastal engineering elsewhere, CERC is the most important research center in coastal engineering and even ocean engineering in the U.S. Therefore CERC has the opportunity and the duty to reenforce this position by becoming an international center of excellence at the forefront of the state of the art and a leader in the profession.

In order to achieve this, a long-term plan and objective should be drawn involving the planning and construction of unique very large hydrodynamics facilities (VLHF). For example, the 3D wave basin at Trondheim (Norways), the 2D wave tank at Hanover, Germany are VLHF which attract scholars, international recognition, and more importantly allow unique research beyond the state of the art. It can be said that the facility of the Franzius Institute in Hanover has solved the limitations imposed by scale effect by carrying out controlled experiments at scale unity! What an opportunity for the researchers! On the other hand, there is no need to duplicate what exists in the other "superlabs". The needs of the Corps should be well identified but I can envision the need for a unique very large 3D basis for the study of sediment transport with directional wave machine, and tidal machinery to investigate shoreline processes and the laws which govern tidal inlets.... Also a very long and large wind-wave-current tank will permit research in an important field which is now bogged

Rosenstiel School of Marine and Atmospheric Science
Division of Ocean Engineering
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4160

down into mathematical intricacies and theories and not enough controlled experiments, etc.

These unique facilities are catalyst for excellence, but we have to face the fact that they will be expensive in capital cost and support personnel. Indeed they should be considered as a long-term commitment of support of a very competent research staff. Encouragement and support should also be given to the academic community, and others, to come and support theoretically the research done in these facilities.

The two foreign facilities already mentioned cost $20M and $9M, respectively, a small amount considering for example that Germany has spent one billion dollars to protect their coastline. How much do we spend in shoreline protection, dredging, flood insurance, etc...?

In this respect the national shoreline study can profitably be updated but only if its main purpose is to provide economic figures demonstrating the cost to the nation of loss in real estate value, shoreline protection, dredging, etc.: the sea as a sink rather than as a source. This study can then be used to promote the superlab at CERC in accordance with the economic needs of our nation.

Indeed, in the U.S., the VLHF can only be done at CERC. Expensive laboratory facilities are not considered as good investment by the private sector, and the academic sector is not supported accordingly. (Practically all the large hydraulic facilities in the world are either government laboratories or are largely subsidized. The Wellingford Laboratory in England has been privatized, but, in the process, it has been given by the government facilities and equipment: no admortization needed. The Sogreah Lab in Grenoble which used to be the second largest lab in the world after WES, has not invested in expensive facilities for a long time.)

Unless there is a dramatic change of policy in the support given by NSF in ocean engineering to academia, CERC is the only place which can serve as a national laboratory for coastal engineering research and development. In any case, if adequate support is given, the universities are more geared towards developing unique smaller facilities - oscillating tanks for example - rather for experimental basic research than applied research. Therefore, CERC should be and is leading agency in coastal engineering.

Finally, in regard to other miscellaneous topics, I would like to point out that by absorbing the wave dynamics group of WES, the role of CERC in harbor engineering has greatly been enhanced de facto. This should be recognized and a SPM-type manual, complementing the design manual of the U.S. Navy, on port and harbor may be considered as most valuable.

It is with regret which I see my most distinguished colleagures Prof. R. Wiegel and W. Bascom terminate their assignment on the board. It was always a pleasure and a great honor to work with them.

Sincerely,

BLeMehaute

Bernard Le Mehaute

BLM:st

APPENDIX E

NARRATIVE RATIONALES AND SPREADSHEETS FOR WORK UNITS

NARRATIVE RATIONALE
COASTAL STRUCTURE EVALUATION AND DESIGN

BACKGROUND

Research and development (R&D) in the Coastal Structure Evaluation and Design Program directly supports and is essential to civil works planning, design, construction, operation, maintenance, and regulatory activities in the coastal zone requiring a knowledge of these effects. Specific civil works missions which depend on and benefit directly from this research are navigation projects in coastal waters, shore protection projects, coastal flood control projects, coastal flood damage prevention projects, and coastal related special and comprehensive projects. Almost all the coastal structure evaluation and design research in the United States is performed by the Corps of Engineers (Corps), and the Corps has almost all United States laboratory facilities and capability necessary to perform this type of research at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Consequently, almost all United States R&D accomplishments in coastal structure evaluation and design are dependent on the Corps.

This research program emphasizes development and advancement of technical methodologies and criteria that are directly applicable to field problems concerning coastal structure evaluation and design. An essential and vital portion of the program is directed toward advancement of the understanding of the response of coastal structures to forces imposed by waves and currents. This element of the program represents a necessary condition for assuring that future R&D achievements will be both significant and directly applicable to field problems.

Detailed content and emphases of this program are formulated from input derived from several complementary sources. The user needs system identifies research needs for this and all other Corps research programs. These needs are prioritized through a comprehensive process containing input for all relevant elements of the Corps. CERC reinforces this identification of priorities by obtaining input directly from coastal engineers in District and Division offices and by personal communications and contacts (with the university community, the industrial community, other Federal and state agencies, and foreign centers of expertise). Additional (or reinforcing) needs are identified by research engineers and scientists of the Corps laboratories and by senior staff engineers of the Office, Chief of Engineers (OCE). Importantly, this research program (and the three other research programs in the Coastal Engineering Area) is overviewed by the Coastal Engineering Research Board (CERB) which advises the Chief of Engineers. The Board is comprised of three Division Engineers and three distinguished civilian members of the coastal engineering community and is chaired by the Deputy Director of Civil Works. The Board uniquely combines and brings to Corps coastal engineering research the managerial vision and foresightedness of general officers responsible for the Corps' coastal missions and the technical understanding of some of the world's foremost coastal engineering authorities.

Corps involvement in coastal structure evaluation and design and the consequent requirement for this research is attested to by the more than 100 major commercial harbors, the more than 300 smaller harbors, the nearly 100 beach and shore protection projects, and the 15 coastal flood protection projects it has built. Almost all these projects involve the design and construction of some type of coastal structure. This convincingly foretells continued involvement and need for the future products of this R&D program.

OBJECTIVES

The objective of this program is to develop technology to more reliably predict the response of coastal structures to the forces to which they are subjected and to evaluate project performance to develop criteria and techniques to ensure design adequacy and economy and express these findings in user product forms for technology transfer. Specific research outputs are used to develop and advance methodology and criteria that the Corps can apply to plan, design, and construct cost-effective and functionally efficient projects. Regulators can apply this methodology and these criteria to reach sound and defensible decisions in permitting structures in navigable waters. Similarly, engineers can apply research results from this program to aid in developing more cost-effective and functionally efficient maintenance actions and programs. Advancement in the understanding of coastal structures' responses to the forces to which they are subjected is a vital underlying objective.

These two objectives are complementary, and the long-term success of the program is dependent on the basic underlying objective. Satisfaction of these objectives requires a carefully balanced mix of theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Research in this program searches for relationships, guidelines, and criteria that lead to problem solutions that are practical, functional, and economical. A heavy emphasis is placed on technology transfer and on expressing these relationships, guidelines, and criteria in user products suited to the capabilities and needs of design and construction engineers.

CURRENT RESEARCH AND DEVELOPMENT

Coastal structure evaluation and design research is composed mostly of experimental laboratory and field investigations and prototype data collection and analysis. This research program provides the funding for some of the major technology transfer mechanisms in the entire Coastal Engineering Area.

Prior Accomplishments

Publication and distribution of 12 Coastal Engineering Technical Notes (CETN's) were made to nearly 400 Corps engineers and scientists directly involved with work or studies in the coastal zone. The fourth edition of the Shore Protection Manual was published and distributed. The draft of an instruction report was completed, and an additional instruction report was initiated. These instruction reports are more detailed than other reports and can stand alone as authoritative texts on their subjects. An evaluation of the performance of the jetties at Murrells Inlet, South Carolina, was completed. Information necessary to evaluate project performance at Little River Inlet, South Carolina; Colonial Beach, Virginia; and Lakeview Park, Ohio, continued. A draft report was completed on the history of erosion control and erosion control efforts at Tybee Island, Georgia. All these evaluations are closely coordinated with District personnel and are often completed with assistance from District personnel.

Full-scale experiments necessary to evaluate the performance of two floating breakwaters in Puget Sound were completed, and analysis and evaluation of the data continued. Planning for a cooperative laboratory investigation of floating breakwaters with the Norweigian Hydrodynamics Laboratory continued (to study a wider variety of wave conditions than encountered during the field tests). A field test of a floating tire breakwater at Pickering Beach, Delaware, was initiated also. Laboratory testing of nonbreaking waves on breakwater heads and angular wave attack on trunk sections continued. A comprehensive inventory of existing Corps breakwaters and jetties was initiated. Tests to determine the percent damage to dolos breakwater sections subjected to breaking waves higher than the design event were completed, and similar tests were initiated for stone breakwater sections. Three reports on the stability and breakage of armor units were published. A workshop on floating tire breakwaters, co-sponsored by CERC and the Canadian National Water Research Institute, was scheduled for November 1984. Data analysis of riprap stability tests using irregular waves and a 1:3.5 embankment slope was completed, and a draft report was prepared. Analysis of low-crested, no-core breakwater test data continued. Preliminary results of low-crested breakwater tests were presented in a technical paper at the 19th American Society of Civil Engineers (ASCE) sponsored International Conference on Coastal Engineering. A first draft Engineer Technical Letter (ETL) on state-of-the-art methods for calculating runup and overtopping was completed.

Expected Accomplishments

In fiscal year 1985 (FY 85) additional CETN's will be completed and distributed to field offices. An Engineer Manual, "Design of Coastal Revetments, Seawalls, and Bulkheads," will be completed. Work will continue on preparation of microcomputer applications for coastal engineering and on an instruction report titled "Sources of Coastal Engineering Information." An additional instruction report will be initiated. Information will continue to be collected on project performance at Colonial Beach, Virginia; Lakeshore Park, Ohio; and Little River Inlet, South Carolina. Reports will be published on the evaluation of the functional performance of the jetties at Murrells Inlet, South Carolina, the history of erosion and erosion control at Tybee Island, Georgia, and the use of offshore breakwaters for shore protection. Draft reports/ETL's will be prepared on the use of side-scan sonar in coastal engineering, floating tire breakwater anchor loadings in shallow water, and comparison tests of different beach and nearshore profiling systems.

Data collection will begin on the history and performance of weir jetty systems, and several numerical models of shoreline response to structures will be evaluated using information collected on project performance. Tests to determine breakwater damages sustained for storm events higher than the design breaking wave will be completed. Work will continue on preparing an inventory and history of existing Corps breakwaters and jetties. Tests of breakwater stability for spectral waves will be initiated. The field report on the Floating Breakwater Prototype Test Program will be published. Evaluation of existing physical model data and numerical model techniques compared with the FBPTP will continue. The Floating tire breakwater workshop will be held, and the workshop proceedings will be published. Tests of riprap stability for a slope of 1:1.5 using spectral waves will be initiated. An ETL and/or technical report on riprap stability results for the 1:3.5 slope will be published. Testing of the low-crested, no-core breakwater concept will continue. An ETL on state-of-the-art methods to predict wave overtopping rates will be published. Laboratory tests of wave runup elevations and overtopping rates using a 1:2 sloped riprap protected embankment will be initiated using irregular waves.

Benefits

Recent and on-going research on both the functional and structural aspects of coastal structures is providing improved guidance to evaluate structure performance and to design more functional, economical structures. This is being accomplished in two basic ways: (1) new classes of structures (i.e., floating breakwaters, low overtopped rubble-mound structures, and offshore breakwaters that are becoming more important to the solution of Corps problems and which have not been adequately studied to date) are being investigated; and (2) studies of the functional and structural stability of coastal structures are being conducted using tools, only recently available, that allow a more thorough and realistic evaluation of their performance. These recently developed tools include laboratory tests using complex wave spectra and highly sophisticated numerical models. As a result, future benefits will include design guidance to the field for new classes of structures and improved guidance which will result in more functional and more economical coastal structures. Another specific benefit will be a revised SPM available not only to the Corps field offices but also to the worldwide coastal engineering community. Comprehensive prototype data will become available on stresses and mooring forces in floating breakwaters, the first such data of its kind. These data will enable laboratory tests and numerical models to be calibrated and verified and to be used to provide comprehensive and reliable design guidance to the field concerning floating breakwaters.

FUTURE RESEARCH

Coastal engineering research will continue to attack problems identified by the user needs system reinforced by the input of District, Division, and OCE coastal engineers, the research staff, and the CERB. Long-range planning is based partly on anticipation of those identifications and largely on the advice of the CERB. Future research in the Coastal Structure Evaluation and Design Program will develop design guidance for floating breakwaters, including realistic information on mooring line loads, wave reduction and internal stress conditions, that is based on field monitoring of existing structures coupled with laboratory experiments and analyses from a new hydraulic/structural numerical model. Design guidance for evaluating the stability of overtopped rubble-mound structures and for evaluating the functional behavior of segmented offshore breakwaters will be developed also. Evaluation of the functional performance of project structures that control and protect navigation channel entrances will be carried out to improve our understanding of their behavior and to provide the basis for design guidance which will improve the effectiveness of such structures. More reliable design information on wave runup on structures and resulting volumes of overtopping water will be developed through tests with wave spectra. Wave spectra will be used also to conduct studies of the stability of riprap structures.

A new advanced class of design capability is evolving for coastal structures. This advanced design capability will be based on reliable directional spectral wave and water level statistics, more reliable basic knowledge of the dynamics of sediment motion, and an improved capability to evaluate the effect of these complex interactions on coastal structures and on specific structure components. The ability to base structure designs on the risk of exceeding the design criteria and the ability to reliably evaluate the consequences resulting from events exceeding the design criteria will emanate from future research products of this program. As a result, output from this program will lead to more accurate and thus most economic design of those classes of structures of most importance to the Corps' coastal civil works missions.

COORDINATION

A number of mechanisms in place and a number of ongoing activities ensure coordination of the Coastal Structure Evaluation and Design research within the Corps, within Government, and within the overall coastal engineering community. One of the most important coordination requirements is that with the other three research programs in the Coastal Engineering Area. Formal coordination is achieved through an annual technical review of work units in the entire Coastal Engineering Area. This review is attended by all principal investigators in the Coastal Engineering Area and is chaired by the Chief, CERC. In addition to this, formal quarterly reviews of milestone achievements are held for all programs in the Coastal Engineering Area. Continued technical coordination is facilitated between programs by participation of most principal investigations on interdisciplinary project teams in more than one program. Certain of these mechanisms and activities (e.g., program reviews, Research and Development Review Board (RDRB) reviews, Laboratory Commanders' Conferences, and annual publication of programs) are common to all Corps research programs. Certain others are unique. The CERB meets semiannually, and its meetings are a forum in which the program is discussed by and with responsible Corps coastal engineers. The presence of leading members of the coastal engineering community from outside the Federal Government on the Board relates the Corps' program to the overall community. Division representatives are invited to technical program reviews conducted at CERC.

Continuing informal contact is maintained with Federal, state, and academic organizations involved in coastal structure evaluation and design research. Close relationships are maintained with key personnel in complementary research areas in foreign laboratories. Joint projects are executed with foreign laboratories when objectives are mutually beneficial. A joint investigation is currently under way with the Norweigian Hydraulics Laboratory. The Chief, CERC, is the present Corps liaison representative to the Marine Board, National Research Council, National Academy of Engineering. This formal position is of immense benefit in assuring excellent coordination of this and other research programs in the Coastal Engineering Area with the industrial, academic, and Federal research communities. Lectures concerning this research program are given by the Chief and key senior staff members of CERC at universities and at professional meetings throughout the United States (and worldwide when possible). Staff members of CERC are heavily involved in activities and programs of all pertinent professional societies. In FY 85, staff members of CERC are serving as members (or chairmen) of various technical committees of the Waterway, Port, Coastal, Ocean Division of ASCE, and technical committees of other professional societies, such as the Permanent International Association of Navigation Congresses. One staff member is serving as a member of the Tsunami Commission of the International Union of Geodesy and Geophysics. The following table shows projected funding for the 5-year research program.

COASTAL STRUCTURE EVALUATION AND DESIGN

PROJECTED FUNDING FOR 5-YEAR RESEARCH PROGRAM

				FY Funding Requirements (in Thousands)						
Priority	Work Unit	Title	Prior Years	CFY FY85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	To Complete	Total
1	31234	Develop Functional and Structural Design Criteria	4,204	500	530	530	550	600	Cont.	Cont.
2	31229	Wave Runup and Overtopping	1,437	100	110	0	0	0	0	1647
3	31232	Evaluation of Navigation and Shore Protection Structures	5,710	330	350	350	400	400	Cont.	Cont.
4	31679	Design of Floating Breakwaters	835	140	150	150	100	50	0	1425
5	31269	Stability of Breakwaters	1,428	240	250	250	250	0	0	2418
6	31680	Riprap Stability to Irregular Wave Attack	540	40	50	0	0	0	0	630
7	31616	Stability of Overtopped Rubble Mound Structures	2,213	120	130	100	100	0	0	2663
8	New	Design of Revetments and Seawalls		0	0	150	200	250	550	1150
9	New	Impact Forces on Breakwater Armor Units Caused by Wave Action		0	0	40	90	200	380	710
10	New	Functional Design Optimization of Coastal Structures		0	0	0	60	200	1190	1450
11	New	Wave Forces and Overtopping on Coastal Structures		0	0	0	0	200	2300	2500
12	New	Scale Modeling of Armor Unit Strength		0	0	0	0	100	510	610
		TOTALS	16,367	1470	1570	1570	1750	2000	Cont.	Cont.

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-D	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
1	31234	Develop Functional and Structural Design Criteria

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 4204	$ 500	$ 530	$ 530	$ 550	$ 600	$ Cont.	$ Cont.

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: The objective is to develop, improve, or affirm guidance on both functional and structural criteria for use in the planning, design, construction, and maintenance of coastal works.

DESCRIPTION OF WORK: Results from R&D of the Corps and others are incorporated into OCE Engineer Manuals, CERC's Shore Protection Manual (SPM), Instructional Reports, The Coastal Engineering Notebook (Coastal Engineering Technical Notes), Miscellaneous Papers, and Category A Computer Programs.

WHY R&D IS NEEDED: The results provide current basic coastal engineering guidance that is applied by CE elements, their contractors and engineers in developing an economic solution for coastal engineering problems on a worldwide basis. This work unit provides the major technology transfer mechanism to field offices from research results in the entire coastal engineering functional area.

MILESTONES AND FORM OF OUTPUT

- CE Tech Notes (Periodic, 3/Qtr)
- Microcomputer Applications for Coastal Engrg Design (Periodic, 1 Category A Computer Program per Quarter)
- Cost Optimization of Rubble-mound Breakwaters (Category A Computer Program) - Apr 85
- MP/Input to EM 1110-2-2904 Aug 85
- Sources of Coastal Engineering Information, IR - Sep 85
- Input to Chapter of EM "Coastal Inlet Hydraulics and Sedimentation" - Mar 86
- Methodology of Wave Data Analysis for Coastal Design, Input to EM "Design Wave Heights and Water Levels" - Dec 86
- Computer Aided Design of Rubble-mound Breakwaters (Category A Computer Program) - Jun 86
- Cost Optimization for Design of Coastal Channels - Mar 87
- Functional Design of Commercial Fishing Harbors - Oct 87
- Applications of Systems Analysis to CE Designs - Mar 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-004-9	Offshore Breakwaters for Coastal Protection	High
21-013-0	Wave Data Analysis Techniques	High
21-020-9	Improvements and Maintenance of Generalized Numerical Hydrodynamic Models	High
22-004-9	Inlet Stability	High
22-006-0	Inlet Hydraulics	High
22-008-4	Planning of Design Consideration for Deep Draft Navigation Channel	High
23-001-8	Guidelines to Establish a Coastal Sediment Budget	High
23-002-8	Guidelines for the Design and Construction of Beach fills	High
23-012-9	Sand Recycling or Renourishment Rates to Establish a Stable Shoreline	High
24-006-9	Weir Jetty Design for Inlet Maintenance and Stabilization	High
24-008-9	Improved Rubble-Mound Design	High
24-012-0	Floating Breakwaters	High
24-014-0	Wave Forces on Nearshore Structures	High
24-016-1	Effects of Submergence on a Jetty, Breakwater, or Groin	High

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET 1 OF 2

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(E R 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-D	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Develop Functional and Structural Design Criteria
WORK UNIT NO 31234	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$4204	$ 500	$ 530	$ 530	$ 550	$ 600	$ Cont.	$ Cont.

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	MISSION PROBLEMS ADDRESSED: NO.	TITLE	FIELD RANK
	Design Procedure for Floating Breakwaters (Update *EM-1110-2-2904*) - Dec 88 SPM Revisions-5th Ed. - Nov 89			

ENG FORM 4413-R, May 81 (Proponent: DAEN RD) SHEET 2 OF 2

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
2	31229	Wave Runup and Overtopping

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$1437	$100	$110	$ 0	$ 0	$ 0	$ 0	$ 1647

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-001-8	Wave Runup and Overtopping	High
24-008-9	Improved Rubble-Mound Design Criteria	High

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop wave runup and overtopping design guidance for use in determining the crest elevation of coastal structures considering the complex character of naturally occurring wave conditions. To produce design curves, tables, and computer programs relating runup elevations and overtopping rates of irregular waves on a variety of structures to the basic characteristics of the structure and wave conditions.

DESCRIPTION: Laboratory experiments will be conducted in two-dimensional wave channels within a wider wave tank. Previous work on this subject has been done only with simple waves of constant period and height. Instantaneous runup elevations and average overtopping rates caused by irregular wave conditions will be measured. Testing conditions will include structures having a variety of slopes, both plane and compound, surface roughnesses and freeboards, as well as range of tow-water depths. A wide range of wave conditions will be used typical of naturally occurring wave trains.

NEED: Wave runup and overtopping are two of the most important factors affecting the design and cost of coastal structures and yet little is known about the behavior of these factors for naturally occurring wave conditions. Two categories of problems have developed because of the limitations in the wave conditions used in the previous laboratory tests. Because of uncertainity about the quantities of overtopping caused by natural wave conditions, many structures have been built unnecessarily high to prevent overtopping. Other designs have overlooked the irregularity of natural wave conditions and unexpected overtopping has resulted. Their current lack of information prevents designers from optimizing the trade-off between overtopping and structure height.

MILESTONES AND FORM OF OUTPUT

Draft MP/ETL infor avail on state-of-the-art overtopping rates - Mar 85

Progress report on measured overtopping quantity for selected revetment/seawall combinations using monochromatic waves - Jun 85

Draft MP/ETL infor avail on FHF beach runup - Jun 85

Progress report on measured overtopping quantity for selected revetment/seawall combinations using spectral waves - Dec 85

Progress report/ETL info avail on laboratory tests of overtopping quantities on 1:2 slope - Sep 86

Comprehensive and/or incremental infor avail for inclusion in update of EM 1110-2-1614, EM 1110-2-2904 or SPM, and training courses - Sep 86

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
2	Wave Runup and Overtopping
WORK UNIT NO. 31229	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$1437	$100	$110	$ 0	$ 0	$ 0	$ 0	$ 1647

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	MISSION PROBLEMS ADDRESSED: NO.	TITLE	FIELD RANK
NEED (Continued): This limitation can be very expensive if the design is too conservative since the cost of a structure is roughly proportional to the square of the height. However, the alternative problem of unexpected overtopping can be even more costly since it could, in the extreme case, result in the failure of the structure.				

ENG FORM 4413-R, May 81 (Proponent: DAEN RD) SHEET 2 OF 2

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCD-S	26 March 1985

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
3	31232	Evaluation of Navigation and Shore Protection Structures

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$ 5710	$ 330	$ 350	$ 350	$ 400	$ 400	$ Cont.	$ Cont.

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: Evaluate and improve upon current techniques employed for the planning, design, construction, and inspection of coastal structures based on field experience and performance of actual projects. Small scale monitoring and field tests are used to: 1) improve inspection and analysis methods, 2) document and interpret structure performance and interactions, and 3) develop or modify design techniques.

DESCRIPTION: For selected projects or portions of projects, functional and structural behavior and effects on adjacent shorelines are documented and reported. Emphasis is placed on rapid response to specific problems or situations as they develop and on developing cooperatively funded monitoring programs. Promising aspects of the data collected under Monitoring Completed Coastal Projects (MCCP) and other field data collection programs are evaluated and expanded. Field studies are conducted to test design technology and improve the methodology for prototype documentation. Based on monitoring programs and field study results, guidelines are derived for the design, construction, or inspection of projects. Techniques are developed and transferred quickly to the field; and research needs identified.

R&D NEEDS: Corps Districts have no direct mechanism for evaluating structural successes and failures and communicating the results to other Districts and agencies. As a result, costly mistakes are sometimes repeated or not even identified until many years later. Even more common is the lack of communication regarding projects that did work well; the reasons why are not identified and therefore no one learns. This work unit is an important means of disseminating information. By monitoring and evaluating features of selected projects through a central system, repetitive mistakes are minimized and successes reinforced. Research needs are identified far enough in advance to be of practical use. New and improved methods for planning design, construction, and inspection

MILESTONES AND FORM OF OUTPUT

FY85

- Offshore Breakwaters for Shore Protection-Draft TR — MAY 85
- Survey System Comparison-Draft MP/ETL/input for Monitoring EM — MAY 85
- Side Scan Sonar-Draft MP/ETL input for Monitoring EM — AUG 85
- Shallow Water Floating Tire Breakwater Field Test — JUL 85

FY86

- Lakeview Park-Draft TR — JAN 86
- Sand Sealing of Jetties-CETN — NOV 85
- EM on Designing Beach Erosion Control Structures — AUG 86
- Airborne Laser Mapping Field Test-Draft MP — MAR 86

FY87

- Shallow Water Floating Tire Breakwater Field Test-Draft MP/ETL — NOV 86

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-004-9	Offshore Breakwaters for Coastal Engineering	High
23-002-8	Guidelines for the Design and Construction of Beachfills	High
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures	High
24-006-9	Weir Jetty Design for Inlet Maintenance & Stabilization	High
14-013-0	Case Histories of Coastal Projects	High
62-001-9	Remote Sensing of Underwater Topography	High
62-016-1	Coastal Inlet Stability and Maint.	Medium

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure. Evaluation and Design		

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
3	Evaluation of Navigation and Shore Protection Structures
WORK UNIT NO	
31232	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY	BFY FY	+1 FY	+2 FY	+3 FY	TO COMPLETE	TOTAL
$	$	$	$	$	$	$	$

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
are brought to the attention of the entire Corps.	Digital Analysis of Survey Map Data-Draft MP/ETL FEB 87 Colonial Beach, VA-Draft TR JUL 87 Sand Sealing of Jetties-Draft MP/ETL SEP 87 FY88 Lakeshore Park, OH-Draft TR NOV 87 Statistical Analysis of Sediment Data-CETN FEB 87 Little River, SC-Draft TR JUL 88 State of the Art of Seawall Design-Draft MP SEP 88 FY89 Revised Methodology for LEO data collection-Draft MP NOV 88 Application of Numerical Models of Sand Transport to Structure Design,-Draft TR MAR 89 Weir Jetty Experience-Draft TR SEP 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET 2 OF 2

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
4	31679	Design of Floating Breakwaters

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 835	$140	$150	$ 150	$ 150	$ 50	$ 0	$ 1425

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To conduct field and laboratory research on commonly used floating breakwater concepts in order to develop adequate design guidance on wave damping ability, anchor and mooring line loads, and connector and internal stresses; to inform field offices of existing state-of-the-art of floating breakwater design practice.

DESCRIPTION: Initially, surveys of the existing literature and current field practice experience with completed floating breakwater projects were completed and reports prepared. The prototype field monitoring program at Puget Sound is being supported including active involvement in the analysis and interpretation of resulting data. Laboratory investigations, including development of a hydraulic/structural numerical model and wave tank tests will be completed. Results of these efforts will include design guidance based on realistic field data from prototype breakwater supported by selected laboratory tests and a versatile numerical model for evaluation of the performance of proposed designs.

NEED: Floating breakwaters can be quite effective in certain situations particularly where deep water conditions exist and/or water levels fluctuate widely such as in reservoirs and high-tide range areas. They also are useful for temporary applications such as the protection of dredges and marine construction equipment. Several floating breakwater systems are being conducted by Corps district during FY 82 and subsequent fiscal years. Designs are based primarily on two-dimensional lab studies under realistic wave conditions. There is an immediate need for design information based on field and lab experiments conducted under more realistic conditions. This will allow districts to eliminate large costs due to excessive conservatism in design required by inadequate design guidance. NPD, for example, estimates savings of $100,000 to $700,000 per site at several sites when the desired design guidane is developed.

MILESTONES AND FORM OF OUTPUT

Floating Tire Breakwater Workshop - Nov 84

Draft MP/ETL infor avail on F3.1P prelim data analysis - Mar 85

Progress report FBPTP final data - Dec 85

Devel phy model tec - Mar 87

Draft MP/ETL infor avail on numerical modeling invest -
Coastal Apr 87
Structural Sep 87

Draft MP/ETL infor avail for design data for practical FB concepts - Sep 88

Design seminar - May 89

Comprehensive and/or incremental infor avail for inclusion in update of EM 1110-2-2904, SPM or design courses - Sep 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-0004-9	Offshore Breakwaters for Coastal Protection	High
24-012-0	Floating Breakwaters	High
24-013-0	Case Histories of Coastal Projects	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
5	31269	Stability of Breakwaters

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 1428	$ 240	$ 250	$ 250	$ 250	$ 0	$ 0	$ 2418

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE. To experimentally develop new and revise existing criteria for the design and rehabilitation of safe and economical rubble-mound and/or aritifcial concrete armor unit breakwaters and jetties.

DESCRIPTION OF WORK: Using physical models of breakwaters, jetties, and armor units, study the stability of both trunk and head sections for various design conditions (i.e., breaking waves, nonbreaking waves, waves at an angle, etc.) so that characteristics such as size and shape of armor units, underlayer material, breakwater crown elevation, energy transmission characteristics, etc. can be determined in an optimal manner.

R&D NEED: Criteria for the design and rehabilitation of rubblemound breakwaters need to be updated and improved to minimize both initial cost and unanticipated maintenance. Improved criteria relating to the dolos concrete armor unit and more quantitative information on the effect of larger size sonte gradation on stability are especially critical. The effect of wave spectra on present design criteria is badly needed also. This work unit is the backbone in establishing and updating design criteria for rubble structures which individually cost millions of dollars. Conservative estimates show that criteria developed under this study results in cost savings of at least $1,000,000 annually on new starts and rehab work. This does not consider saving in maintenance cost or cost and loss of life and property if failure occurred due to the lack of such criteria. In short this research is needed to assume development of sound, safe, and cost-effective wave protection.

MILESTONES AND FORM OF OUTPUT

Draft update report of EM 1110-2-2904 - Dec 84

Revised draft of EM 1110-2-2904 - Jun 85

Draft TR/ETL infor avail on stone and dolos percent damage tests, breaking waves - Jul 85

Final draft of EM 1110-2-2904 - Sep 85

Report on Inventory of Breakwaters - Jan 86

Draft TR/ETL infor avail on stone and dolos head tests, nonbreaking waves - Jun 86

Draft TR/ETL infor avail on stone trunks, wave spectra - Sep 86

Draft TR/ETL avail on stone and dolos head tests, breaking waves - Mar 87

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-008-9	Improved Rubble-Mound Design Criteria	High
21-001-8	Wave Runup and Overtopping	High
13-037-9	Rehabilitation of Older Civil Works Structures	High
21-004-9	Offshore Breakwaters for Coastal Protection	High
24-016-1	Effects of Submergence on Jetty, Breakwater or Groins	High
24-014-1	Wave Forces on Nearshore Structures	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
5	31269	Stability of Breakwaters

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 1428	$ 240	$ 250	$ 250	$ 250	$ 0	$ 0	$ 2418

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	Draft TR/ETL infor avail on dolos trunks, wave spectra - Dec 87 Incremental and/or comprehensive information available for inclusion in update of EM 1110-2-2904 and/or SPM - Jun 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 25

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
6	31680	Riprap Stability to Irregular Wave Attack

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 540	$ 40	$ 50	$ 0	$ 0	$ 0	$ 0	$ 630

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To produce design curves and equations which relate riprap stability to the characteristics of naturally occurring wave conditions.

DESCRIPTION: Initially, scale effects tests will be conducted in the CERC wave tanks which will replicate previous prototype scale riprap stability tests conducted in the Large Wave Tank. Comparisons in damage levels between large- and small-scale tests will be used to determine scale effects. Then tests will be conducted to compare revetment damage trends and natural irregular waves for a range of wave, structure and water level conditions. Riprap stability on steep slopes also will be investigated so that the results from this study can be compared to the results of rubble mound breakwater studies.

NEED: The effects that naturally occurring wave trains have on riprap and rubble mound stability are not fully understood nor have they been adequately modeled in previous laboratory tests which have primarily used monochromatic waves (waves of constant height and period). Irregular waves, that model naturally occurring waves, are being used in the tests but at small scale making it important that the extent of scale effects be known to evaluate experimental results. With improved and more realistic design criteria development from the irregular wave tests, less conservative (and thus more economic) structure designs can be used. Each year, large sections of shoreline revetment are constructed so immediate research in this area will be quite cost effective.

MILESTONES AND FORM OF OUTPUT

Draft TR/ETL infor avail on stability and runup data for 1:3.5 and 1:1.5 slope - Apr 86

Comprehensive and/or incremental infor avail for inclusion in update of EM 1110-2-1614, SPM and/or training courses - Sep 86

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-001-8	Wave Runup and Overtopping	High
21-007-9	Predicting Wave Conditions in Shallow Water	High
24-008-9	Improved Rubble Mound Design Criteria	High
24-010-9	Riprap Stability Under Irregular Wave Attack	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
7	Stability of Overtopped Rubble-Mound Structures
WORK UNIT NO.	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 2213	$ 120	$ 130	$ 100	$ 100	$ 0	$ 0	$ 1150

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

<u>OBJECTIVE</u>: To develop design criteria for the stability of randomly placed stone and concrete armor on the front side, back side, and crest of low rubble mound structures, as well as to determine the wave transmission over and through rubble-mound structures subjected to a full range of wave and water level conditions.

<u>DESCRIPTION OF WORK</u>: Experiments will be conducted at both large and small scales. Testing in the small tank will cover the full range of conditions, including depth limited wave spectra, while large-scale testing will help relate the small tank tests to field conditions. Emphasis will be placed on low-crested, easily-overtopped structures. Structure design will include both traditional three-layer cross sections and cross sections with no core. The designer will be able to use this stability and wave transmission information to optimize the dollar savings in the improved design of the structure at various elevations with the corresponding degrees of risks to the facilities located behind the structure, or the degree of protection afforded the shoreline or beach.

<u>NEED</u>: At present there are no specific criteria for designing rubble structures subject to frequent overtopping and all such structures must undergo extensive and expensive site-specific model testing to develop a design. As economics increase the cost of rubble structures, engineers are more frequently lowering the rest evaluation (and thus the cost) of such structures and increasing the risk to the facilities, shoreline, or beach being protected.

MILESTONES AND FORM OF OUTPUT

Progress report/ETL infor avail for updated analyses for low-crested nocore breakwater - May 85

MP/ETL infor available on stability and wave energy dissipation characteristics of low-crested no-core breakwaters - May 1986

MP/ETL infor available on low-crested 3-layer stone structures - Jul 87

MP/ETL infor available on low-crested concrete armored structures - Apr 88

Final Workshop - Jun 88

Comprehensive and/or incremental infor available for inclusion in update of EM 1110-2-2904 and/or SPM - Sep 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-001-8	Wave Runup and Overtopping	High
21-022-2	Wave Transformation on Reefs	High
21-004-9	Offshore Breakwaters for Coastal Protection	High
21-007-9	Predicting Wave Conditions in Shallow Water	High
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures	High
24-008-9	Improved Rubble-Mound Design Criteria	High
24-016-1	Effects of Submergency on a Jetty, Breakwater, or Groin	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structures Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
8	327 NEW	Design of Revetments and Seawalls

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$	$ 150	$ 200	$ 250	$ 550	$ 1150

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

<u>OBJECTIVE</u>: , To develop procedures to optimize the design of riprap revetments. To produce design curves, tables, and computer programs relating the characteristics of the revetment to the characteristics of naturally occurring wave trains.

<u>DESCRIPTION</u>: Laboratory tests of riprap stability and wave runup will be conducted in a two-dimensional wave tank and tests involving wave overtopping will be conducted in a two-dimensional wave channel within a wider wave tank. Most tests will use irregular wave conditions similar to naturally occurring wave trains with some monochromatic conditions to replicate dimensionless parameters used in previous large-scale tests. Several embankment slopes will be used compatible with previous related efforts. Revetment characteristics include armor stability, wave runup elevations, wave reflection and overtopping rates, and wave characteristics include the significant wave height, period of maximum wave energy density, wave spectral width, and wave grouping.

<u>NEED</u>: There is increasing need for up-to-date information on the performance characteristics of riprap revetments exposed to irregular wave attack. Because of the enormous increase in computing power in recent years the ability to develop complex optimum type designs can be invisioned but the data base for such an effort is either lacking or its value can be questioned. Much of the data are based on laboratory tests using monochromatic waves (waves of constant height and period).

MILESTONES AND FORM OF OUTPUT

ETL infor avail dumped graded riprap stability - Aug 88

ETL infor avail on scale effects - Sep 88

ETL infor avail on overtopping rate for 1:3.5 slope - Sep 90

ETL infor avail on runup for medium slopes (1:3 and/or 1:4) - Mar 91

Comprehensive infor avail for inclusion in update of EM on Design of Revetments, Seawalls, and Bulkheads

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-010-9	Riprap Stability Under Irregular Wave Attack	High
21-001-8	Wave Runup and Overtopping	High
24-008-9	Improved Rubble-Mound Design Criteria	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY (ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structures Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
9	Impact Forces on Breakwater Armor Units Caused by Wave Action

WORK UNIT NO. 327 NEW

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$	$ 40	$ 90	$ 200	$ 380	$ 710

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To determine the wave impact loading on individual concrete armor units of rubble-mound breakwaters so that criteria for quantifying more realistic reinforcing steel requirements can be established and initial construction and rehabilitation costs can be optimized.

DESCRIPTION OF WORK: Large scale model breakwaters and armor units will be used in which a sufficient number of the selected types of armor units (dolosse and tribars) will be specially instrumented to measure the dynamic impact forces developed as the units are subjected to direct wave impact and to free-rocking, tumbling, and rolling caused by breaking and nonbreaking wave attack. Data on the impact force which the moving unit has on inplace units also will be obtained. The basic tests will be conducted on breakwater trunk sections using monochromatic and/or spectral wave conditions at a 90 degree angle of incidence. Additional, but limited, tests then will be conducted for units on a breakwater head and trunk combination for at least two different angles of wave attack to determine the impact forces on breakwater heads and the effect angular wave attack has on impact forces.

R&D NEEDS: The magnitude of dynamic wave forces on concrete breakwater armor units are required by the FOA's to realistically determine a sufficient and proper amount of armor reinforcing steel for specific design or maintenance conditions. No realistic way of predicting impact loading caused by waves moving individual units presently exists; thus, present practice seems to be to over design the structural reinforcing to assure no excessive breakage.

MILESTONES AND FORM OF OUTPUT

Information available for ETL on 2-Dimensional Results Dec 90

Information available for ETL on 3-Dimensional Results Dec 92

Final Data available for inclusion in update of SPM, EM 110-2-2904 and SR-5- Apr 93

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
14-022-1	Concrete Armor Unit Construction Design Criteria	High
24-008-9	Improved Rubble-Mound Design Criteria	High
24-014-0	Wave Forces on Nearshore Structures	High
14-008-9	Strength Design of Concrete Hydraulic Structures	High

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCD-S	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
10	Functional Design Optimization of Coastal Structures
WORK UNIT NO: NEW	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 0	$ 0	$ 60	$ 200	$ 1190	$1450

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To systematically study navigation control structures (i.e. jetties, offshore breakwaters, etc.) and shore protection structures (offshore breakwaters, groins) using cost, sand transport climatology, and sand transport variability to optimize design for varying locations and sand transport time series scenarios.

DESCRIPTION: Possible approaches to optimization of structures include structure orientation (i.e. "tuning") to the directional wave climate for prevention of fillet formation and bar growth. Structures which provide an adequate data base (synthesized wave climatology, surveys, system cost, etc.) will be studied to ascertain expected performance of the system and compared to actual performance. Particular emphasis will be placed on documentation of the stochastic nature of the sand transport (i.e. variability of net and gross sand transport along with particular time sequencing). A coupled stochastic time series model along with existing numerical shoreline models will be used to study system performance. Field and/or laboratory tests will be made of planned improvements to inadequate systems. Documentation of systems studied and rationale for optimal structure design incorporating cost and sand transport climatology will be compiled into report form.

R&D NEEDS: Approximately 50 percent or more of presently designed coastal structures do not perform as expected, and many are complete failures in view of the functions they are designed to provide. Inadequate systems increase maintenance cost. Optimal design of structures needs to be approached in a systematic fashion which integrates economics, sand transport climatology and variability, and physical performance of the system. This approach could easily result in a substantial improvement in structure performance and significant reductions in maintenance costs.

MILESTONES AND FORM OF OUTPUT

Milestone	Date
Draft report on systems to be studied and data base	Sep 89
Draft report on synthesized directional wave climate and sand transport statistics at study sites	Sep 90
Symposium/Workshop on Coastal Structure Design	Sep 91
Draft report on modeling of sand transport at study sites and comparison to prototype behavior	Sep 92
Draft report on prototype improvement studies	Sep 93
Draft final report on systematic approach to structure design	Sep 94
Input to EM	Sep 94

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-013-0	Case Histories of Coastal Projects	High
25-006-9	Weir Jetty Design for Inlet Maintenance and Stabilization	High
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures on Shorelines	High
22-008-9	Planning of Design Considerations for Deep Draft Navigation Channels	High
32-006-9	Navigation Channel Stabilization and Maintenance	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCR-O WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO.	TITLE
11	New	Wave Forces and Overtopping on Coastal Structures

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 0	$ 0	$ 0	$ 200	$ 2300	$ 2500

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop wave force and wave pressure design criteria based on realistic wave characteristics for various types of coastal structures commonly used in the Corps.

DESCRIPTION OF WORK: Recent literature on wave force and wave pressure design procedures will be reviewed and summarized. Several structure configurations of maximum interest to the Corps, such as rubble-mound structures, crown walls atop rubble structures, and regular vertical or recurved walls, will be selected for study. The study will consist primarily of development of a generalized theoretical and numerical model and extensive laboratory testing of the specific configuration selected. The theoretical/numerical model and the laboratory tests will include consideration of the effects of irregular waves and directional spreading of energy. Laboratory investigations will include both two-dimensional (direct wave attack, surface and subsurface pressures, cyclic foundation loading) and three-dimensional (angular wave attack, directional spreading, etc.) modeling efforts with some tests using the directional spectral wave generator. Two-dimensional laboratory tests with rubble-mound structures will include both stone and dolos armor on at least three different slopes to bracket wave forces on the two most realistic but different surface textured and stratified rubble-mound breakwater designs used today. Numerical and laboratory results will be used to develop improved wave force and wave pressure prediction techniques for coastal design. Results may also be used for estimating cyclic wave loading of structure foundation materials. Results for at least one configuration will be further validated by prototype scale measurements in the vicinity of the Field Research Facility.

R&D NEEDS: Present methods for predicting wave forces on coastal structures are derived from work with long-crested, regular waves impacting

MILESTONES AND FORM OF OUTPUT

MP Literature Review - Sep 90.

Completion of Model Instrumentation Setup - Sep 90.

CETN Estimating Wave Forces for Directionally Spread Irregular Waves - Sep 91.

Infor for ETL on Nonbreaking Wave Test Results - Sep 92.

CETN Laboratory Modeling of Wave Forces - Jan 93.

Workshop Wave Forces - Apr 93.

Infor for ETL on Breaking Wave Test Results - Sep 94.

Documentation Wave Force Estimation Program - Sep 95.

Workshop Wave Forces for Design - Nov 95.

TR Wave Forces for Design - Sep 96.

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-014-0	Wave Forces and Nearshore Structures	High
24-008-9	Improved Rubble-Mound Design Criteria	High
24-010-9	Riprap Stability Under Irregular Wave Attack	High
14-004-8	Soil Structure Interaction Studies	High
14-008-9	Strength Design of Concrete Hydraulic Structures	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structure Evaluation and Design	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
11	New	Wave Forces and Overtopping on Coastal Structures

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 0	$ 0	$ 0	$ 200	$ 2300	$2500

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
vertical walls. Present prediction methods appear to differ significantly from the few actual measurements available. There is a strong need in the Corps for more realistic and more accurate wave force estimation techniques for structure design and performance evaluation. Results will be directly applicable to the engineer manuals on Design of Breakwaters and Jetties and Design of Coastal Revetments, Seawalls, and Bulkheads.	Comprehensive and/or incremental data available for inclusion in SPM, training courses, update of EM "Design of Breakwaters and Jetties" and/or EM "Design of Seawalls, Bulkheads, and Revetments".

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structures Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
12	327 NEW	Scale Modeling of Armor Unit Strength

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 0	$	$	$ 100	$ 510	$ 610

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To determine modeling relationships and materials that effectively reproduce the structural characteristics (breaking strength, elasticity, etc.) of prototype concrete armor units used for breakwater, dam, shoreline, and streambank protection.

DESCRIPTION OF WORK: A review will be made of the technical literature to determine the state-of-the-art of modeling structural materials and to determine the pertinent variables that describe modeling of the structural characteristics of concrete. From the variables to be considered, select those variables that are most important with respect to coastal hydraulic modeling and determine their specific type armor units, say dolos, made of prototype concrete normally used in such projects, perform tensile, compression, shear and torsional load tests to determine particular failure planes and loadings. This will provide a basis for scaling and comparing proposed model materials. Considering structural properties selected, investigate existing commercial and/or specifically produced materials that might be suitable for modeling armor units. Each material proposed will have to be tested for its ability to satisfy structural similitude requirements as well as stability similitude requirements (i.e., density and weight). Once a realistic and practical model scaling relationship and material are determined, a sufficient number of the special armor units will be made for two different model scales and limited stability tests conducted to verify the scaling relationship.

MILESTONES AND FORM OF OUTPUT

Info for ETL or Tech Note on Feasibility of Structural Modeling - Sep 89

Data for ETL or Tech Note on Model Materials Simulation Oct 91

Data for ETL or Tech Note on Wave Flume Results - Jan 92

Comprehensive data available for inclusion in SR-5, Training courses, or update of EM 1110-2-2904 - Sep 92

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
14-022-1	Concrete Armor Unit Construction Design Criteria	High
24-008-9	Improved Rubble-Mound Design Criteria	High

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Structures Evaluation and Design	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO.	TITLE
12	327 NEW	Scale Modeling of Armor Unit Strength

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 0	$	$	$ 100	$ 510	$ 610

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
R&D NEEDS: Present modeling practice for concrete armor units takes into consideration the individual weight, specific weight, and geometry of the prototype armor. However, structural characteristics of the units are not simulated; thus, present model results assume that the prototype units will not be structurally abused or a significant number will not be broken. In today's world of economic designs (optimumization by weight), concrete units which interlock more efficiently but are structurally weaker than previous units have been invented and used. This fact, emphasized by the dramatic failure of the Sines Breakwaters and coupled with the uncertainties of calculating actual wave loadings, has emphasized the critical need for additional design guidance on the structural abuse that individual concrete armor units can experience before breaking. The specific need is the ability to investigate structural characteristics of concrete armor units in the laboratory during the design phase of the breakwater. This capability does not now exist. Other potential benefits would be more efficient and economical designs, lower maintenance cost, safer structures, and a quantification of the ability to reliably estimate the dollar trade offs between initial cost and expected maintenance.	

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

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NARRATIVE RATIONALE
HARBOR ENTRANCES AND COASTAL CHANNELS

BACKGROUND

Research and development (R&D) in the Harbor Entrances and Coastal Channels Program directly supports and is essential to civil works planning, design, construction, operation, maintenance, and regulatory activities in the coastal zone requiring a knowledge of these effects. Specific civil works missions which depend on and benefit directly from this research are navigation projects in coastal waters, coastal related special and comprehensive projects, and coastal flood damage prevention projects. Most of the harbor entrances and coastal channels research in the United States is performed by the Corps of Engineers (Corps), and the Corps has almost all laboratory facilities and capabilities necessary to perform this type of experimental research at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Consequently, the United States' R&D accomplishments in harbor entrances and coastal channels are almost totally dependent on the Corps.

This research program emphasizes development and advancement of technical methodology and criteria that are directly applicable to field problems concerning harbor entrances and coastal channels. An essential and vital portion of the program is directed toward advancement of the understanding of physical processes that govern the hydrodynamics and sedimentation of harbor entrances and coastal channels. This element of the program represents a necessary condition for assuring that future R&D achievements will be both significant and directly applicable to field problems.

Detailed content and emphases of this program are formulated from input derived from several complementary sources. The user needs system identifies research needs for this and all other Corps research programs. These needs are prioritized through a comprehensive process containing input from all relevant elements of the Corps. CERC reinforces this identification of priorities by obtaining input directly from coastal engineers in District and Division offices, by personal communications and contacts (with the university community, the industrial community, other Federal and state agencies, and foreign centers of expertise), and by periodic visits to each field office.

Additional (or reinforcing) needs are identified by research engineers and scientists of the Corps laboratories and by senior staff engineers of the Office, Chief of Engineers (OCE). Importantly, this research program (and the three other research programs in the Coastal Engineering Area) is overviewed by the Coastal Engineering Research Board (CERB) which advises the Chief of Engineers. CERB is comprised of three division engineers and three distinguished civilian members of the coastal engineering community and is chaired by the Deputy Director of Civil Works. CERB uniquely combines and brings to Corps coastal engineering research the managerial vision and foresightedness of general officers responsible for the Corps' coastal missions and the technical understanding of some of the world's foremost coastal engineering authorities.

Corps involvement in harbor entrances and coastal channels and the consequent requirement for this research is attested to by the more than 100 major commercial harbors and more than 300 smaller harbors it has built. In late 1983, the Corps had over 25 major harbor projects and over 30 smaller harbor projects in various stages of active planning and design to which output from this research program is directly related. This convincingly foretells continued involvement and need for the future products of this R&D program.

PROGRAM OBJECTIVES

The objective of this program is to develop technology to reliably predict and describe the interactions of waves, currents, and sediments in and around harbor entrances, inlets, and coastal channels. Specific research outputs are used to develop and advance methodology and criteria that the Corps can apply to plan, design, and construct cost effective and functionally efficient harbors and coastal navigation channels. Regulators can apply this methodology and these criteria to reach sound and defensible decisions in permitting projects whose function and design may impact on a harbor entrance or coastal navigation channel. Similarly, engineers can apply research results from this program to aid in developing more cost effective and functionally efficient maintenance actions and programs. Advancement in the understanding of the physical processes that govern the hydrodynamics and sedimentation of harbor entrances and coastal channels is a vital underlying objective.

Satisfaction of these objectives requires a mix of theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Research in this program searches for relationships, guidelines, and criteria that lead to problem solutions that are practical, functional, and economical. Emphasis is on expressing these relationships, guidelines, and criteria in user products suited to the capabilities and needs of design and construction engineers in the Corps.

CURRENT RESEARCH AND DEVELOPMENT

Harbor Entrances and Coastal Channels research includes theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Currently the majority of emphasis and resources are placed on theoretical and numerical investigations and data collection and analysis. All the research is assigned to WES.

Prior Accomplishments

Shoaling of inlet bars is a continuing problem in the Corps' effort to maintain adequate navigation depths, and a better understanding of the physical processes responsible for this shoaling is basic to developing design criteria aimed at reducing costs of project maintenance. Literature on inlet shoaling rates and patterns and on techniques for predicting shoaling rates was evaluated. Data, including aerial photographs and dredging histories for two possible sites for a definitive field experiment on tidal inlets, were collected. No comprehensive source of information or guidance is available which describes planning and selection procedures for sand bypassing systems. Such systems, used to pass sand across tidal inlets or harbor entrances, rely primarily on intensive project development. Work on compiling a systemic approach to the design and selection of sand bypassing systems will reduce project costs considerably. Initial steps in the work were completed, including a detailed literature search, compilation of a complete list of references, and a methodology for characterizing the problem and describing the basic concepts of sand bypassing systems. Wave-current interactions at entrances to tidal inlets and harbors can produce dangerous conditions for both small craft and ships attempting to navigate through these entrances. Wave-current interactions have a major influence on sedimentation in entrance channels and adjacent coastal areas. Development of a large grid mesh numerical model of wave/current interactions applicable to investigating and quantifying these problems was started. A comprehensive knowledge of the nearshore waves and currents in the vicinity of harbor entrances and coastal channels is basic to developing improved guidance to minimize channel shoaling. The lack of reliable and quantitative methods for the prediction of nearshore waves and currents was partially alleviated by completion of a literature review and state-of-the-art report on nearshore currents. Results of this report were used to develop a preliminary numerical model for prediction of nearshore waves and currents. This technology was transferred to field personnel by means of a workshop. A field experiment was held at CERC's Field Research Facility (FRF) in conjunction with investigators from the US Geological Survey (USGS) and Oregon State University to collect quantitative data which were compared with model predictions.

Expected Accomplishments

Representative tidal inlets will be further studied to better quantify inlet channel geometry changes as a function of reversals in sediment transport direction, offshore bar position, and the wave climate. Data collected at these inlets and that previously collected will be analyzed and a report prepared which should allow field personnel to design inlet improvements and predict future channel shoaling patterns and rates with an increased level of confidence that a reasonably stable navigation channel can be maintained through the offshore bar. Input to an Engineer Manual (EM) will be prepared to provide explicit guidance on calculating channel shoaling rates. Work will be completed on an EM which will provide information and methodology needed to select all feasible alternative bypass designs for a particular problem site at which sand bypassing may be used. Development and testing of a large grid mesh numerical model will be completed for the study of waves at entrances. Development of a complementary small-scale model for wave propagation at entrances will be completed. The nearshore circulation model will undergo continued development and testing. A more comprehensive field experiment will be conducted at the FRF jointly with other agencies to provide additional critical data for model verification. Program results will be used to write or revise EM's on Coastal Inlet Hydraulics and Sedimentation and Littoral Transport Estimates for Coastal Engineering.

Benefits

Research in this program is aimed at understanding hydrodynamic and sediment transport processes that affect harbor entrances and coastal channels and to use this knowledge to improve Corps capabilities for designing safe and economical coastal navigation channels. To this end, research results from this program will improve the Corps' ability to predict the amount and frequency of maintenance dredging that a proposed navigation channel might require, and perhaps, more importantly, to better predict changes in maintenance dredging requirements caused by proposed channel modifications. These research results should lead to reduced maintenance costs and will unequivocally result in a better economic assessment of these costs in the planning and design state of coastal navigation projects. When structures are built at inlets to keep sediment from entering the navigation channel, erosion of adjacent beaches can result. One method of avoiding adverse effects to adjacent beaches is to provide for a sand bypassing system. This program will lead to guidelines for selecting the best sand bypassing system for a given site. The pros and cons of various systems will be defined and design procedures, data requirements, etc., will be detailed. The safety of both small craft and ships navigating inlet or harbor entrance channels depends critically on wave conditions at the entrance. These waves are often dangerously steep due to ebbing tidal currents. A more comprehensive knowledge of the effect of currents on waves will permit the design of navigation entrances that minimize adverse wave conditions. Inlet currents coupled with waves are responsible for sediment transport in and shoaling of coastal navigation channels. The knowledge gained through research under this program will ultimately lead to a better capability to predict the movement of sediment in the vicinity of inlets by waves and currents and thus allow the design of improved navigation channels.

Maintenance dredging at tidal inlets is a continuing cost if safe navigation is to be assured. The source of most sediment reaching the navigation channel is the offshore shoals and beaches adjacent to the inlet. The sediment is driven to the inlet by wave-induced nearshore currents. Understanding the mechanism for the generation of these currents and their ability to transport sediment is prerequisite to understanding the sedimentation/shoaling processes in inlets, harbor entrances, and coastal channels. Benefits of such knowledge are an improved quantitative prediction of channel shoaling rates and longshore transport rates and a much improved ability to estimate nearshore current conditions which will directly translate to more functional and more economical designs for inlet navigation channel improvements (such as jetties, sand bypassing systems, etc.).

This research program benefits substantially from research progress in the understanding of waves and wave transformation under the Coastal Flooding and Storm Protection Program and from improvements in our understanding of basic sediment dynamics in the coastal zone under the Shore Protection and Restoration Program. Likewise, research results from this program form a valuable input to the Coastal Structure Design and Evaluation Program since an improved description of wave/current interactions is basic to improving design criteria for coastal navigation structures.

Long-term benefits will result in improved functional design methodology for jetties and coastal navigation channels, the ability to numerically model the hydrodynamics and sedimentation in harbor entrances and tidal inlets, and the development of new and improved design criteria for navigation channels in tidal inlets.

FUTURE RESEARCH

Research in harbor entrances and coastal channels will continue to address problems identified by the user need system reinforced by input from coastal engineers in the field offices and in OCE, the CERC research staff, and CERB. Long-range planning is based partly on anticipation of these needs and largely on input and advice from CERB. Past research in harbor entrances and coastal channels has given the Corps reasonably good qualitative understandings and conceptual models of the physical processes involving the hydrodynamics and sedimentation of harbor entrances and coastal channels. Based on these understandings, physical and numerical models, and judiciously selected field observations, the Corps has developed what should be termed a first-generation design capability in this area. Research, primarily theoretical and numerical modeling and field experiments, is leading to the development of much more quantitative models and is adding sophistication to our understanding of the hydrodynamics and sedimentation of harbor entrances and coastal channels. Future research will focus heavily on quantification of conceptual models. This research will produce a second generation design capability for projects related to harbor entrances and coastal channels. This second generation design capability will be based on reliable directional spectral wave statistics, and it will enable the designer to not only base his design on mean annual channel shoaling rates but also to analyze the risk that these mean rates will be exceeded and to know the consequences of each level of risk evaluated. Future research in harbor entrances and coastal channels will include development of methods for better predicting navigation channel maintenance requirements and input to several EM's concerning information on sand bypassing system selection. A user's guide will be produced for numerical models that describe waves and currents at navigation entrances, and those models will be improved to deal with more complex situations. Workshops will be held on the use of models developed for describing nearshore currents. Field testing of the nearshore current models for verification purposes will be performed with the aim of making further model improvements. User guides for the models will be produced for Corps Divisions and Districts. Future work will be directed also toward developing more quantitative numerical models for representing the hydrodynamics and sedimentation of tidal inlets, developing better criteria for the functional design of jetties, quantifying the characteristics of ship generated waves, and developing new, improved criteria for the design of harbor entrances and coastal navigation channels.

COORDINATION

A number of mechanisms in place and a number of on-going activities ensure coordination of the Harbor Entrance and Coastal Channels research within the Corps, within Government, and within the overall coastal engineering community. One of the most important coordination requirements is that with the other three research programs in the Coastal Engineering Area. Formal coordination is achieved through an annual technical review of work units in the entire Coastal Engineering Area. This review is attended by all principal investigators in the Coastal Engineering Area and is chaired by the Chief of CERC. In addition to this, formal quarterly reviews of milestone achievements and fiscal status are held for all programs in the Coastal Engineering Area. Certain of these mechanisms and activities (e.g., program reviews, Research and Development Board reviews, Laboratory Commanders' Conferences, and annual publication of programs) are common to all Corps research programs. Certain others are unique. CERB meets semiannually, and its meetings provide a forum in which the program is discussed by and with responsible Corps coastal engineers. The presence of leading members of the coastal engineering community from outside the Federal government on the Board relates the Corps' program to that of the overall community. CERC representatives visit coastal Divisions and Districts periodically and discuss the program. Division representatives are invited to technical program reviews conducted at CERC each year.

Continuing informal contact is maintained with Federal, state, and academic organizations involved in harbor entrances and coastal channel research. Particularly close relationships are maintained with key personnel in complementary research areas in various offices of the National Oceanic and Atmospheric Administration, the US Navy, and the USGS. Joint projects with other agencies and organizations are undertaken whenever there is a mutual benefit. The Chief of CERC is the present Corps liaison representative to the Marine Board, National Research Council, National Academy of Engineering. This formal position is of immense benefit in assuring excellent coordination of this and other research programs in the Coastal Engineering Area with the industrial, academic, and Federal research community. Lectures concerning this research program are given by the Laboratory Chief and key senior staff members of CERC at universities and at professional meetings throughout the United States (and worldwide when possible). Staff members of CERC are heavily involved in activities and programs of all pertinent professional societies. A number of staff members serve as members (or chairmen) of various technical committees of the various coastal engineering related professional societies.

HARBOR ENTRANCES AND COASTAL CHANNELS

					FY Funding Requirements - Thousand Dollars						
Priority	Number	Work Unit Title	Performing Laboratory	Prior Years	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	To Complete	TOTAL
1	31716	Inlet Bar Channel Shoaling	CERC	583	245	245	340	185	0	0	1598
2	31760	*Sand Bypassing System Selection*	CERC	210	75	75	55	0	0	0	415
3	31673	Waves at Entrances	CERC	920	240	240	270	230	100	0	2000
4	31672	Nearshore Waves and Currents	CERC	1505	235	235	230	200	0	0	2405
5	31676	Dispersive Transport in Distorted Estuarine Channels	HL	425	0	0	0	75	0	0	500
6	NEW	Inlet Stability	CERC	0	0	0	0	100	160	240	500
7	NEW	Advanced Data Acquisition Methods and Equipment for Coastal Inlets	CERC	0	0	0	0	100	200	995	1295
8	NEW	Improved Long Wave Modeling of Ports and Harbors	CERC	0	0	0	0	50	200	1150	1400
9	NEW	Sediment Transport Modeling at Inlets	CERC	0	0	0	0	50	200	770	1020
10	NEW	Numerical Simulation of Directional Spectral Waves in Harbors	CERC	0	0	0	0	0	120	880	1000
11	NEW	Forecasting Hazardous Conditions in Coastal Channels	CERC	0	0	0	0	0	110	1390	1500
				3643	795	795	895	990	1090	5425	13,633

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Inlet Channel Shoaling Stability
WORK UNIT NO	
31716	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 583	$ 245	$ 280	$ 350	$ 140	$ 0	$ 0	$ 1,598

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To define and quantify the dominant processes which *control the shoaling and stability of tidal inlets* and channels extending across ebb-tidal deltas. To develop design guidelines for predicting shoaling patterns and rates in these channels through the analysis of existing *field* and laboratory data and, where necessary, collection of additional field data.

DESCRIPTION OF WORK: Existing literature as well as *field* and laboratory data are being reviewed and evaluated. Results of the General Investigation of Tidal Inlets (GITI) investigations will be incorporated into this work. A comprehensive review/users' report summarizing the *GITI* program will be produced permitting dissemination of the GITI study results under one cover. Techniques for determining inlet and channel stability and sediment transport will be reviewed, developed, and verified. These results will be used at the district level. Verification of these techniques will be accomplished through evaluations of existing data in Corps district offices and, where necessary, a field data collection program will be implemented.

R&D NEEDS: Dredging costs are rising rapidly. In order to effectively plan, evaluate, and design *modifications to inlet systems*, the Corps must gain a better understanding of the dominant processes which control inlet and channel shoaling and stability. This will lead to more efficient inlet and channel modification designs, thus producing *a real cost savings to the Corps of* Engineers.

MILESTONES AND FORM OF OUTPUT

FY 85

Misc. Report: Annotated Bibliography on Tidal Inlet Investigations - Apr 85

Tech. Report: State-of-the-art Report on Numerical and Field Investigations on Tidal Inlet Systems - May 85

Tech. Report: Review on Shoaling Prediction Techniques - Sep 85

Field Experiment - FRF 85 - Provide verification of wave and sediment transport techniques - Sep 85

FY 86

Tech. Report: A Micro-Computer Technique for Predicting Channel Shoaling Rates -Sep 86

Misc. Report: A summary report on the GITI program - Sep 86

-continued-

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
32-001-8	Navigation Channel Dimensions and Alignment	High
32-006-9	Navigation Channel Stabilization	High
32-017-0	Channel Alignment	High
22-004-9	Inlet Stability	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Inlet Channel Shoaling Stability
WORK UNIT NO. 31716	

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 583	$ 245	$ 280	$ 350	$ 140	$ 0	$ 0	$1,598

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	Field Experiment - DUCK 86-Techniques developed in FRF-85 will provide simultaneous wave and current and sediment transport measurements - Sep 86 FY 87 Misc. Report: Preliminary Analysis of DUCK 86 Field Experiment - JAN 87 Tech. Report: Evaluation of Shoaling Prediction Techniques - Dec 86 Joint Field Experiment on an Ebb Tidal Delta Eng. Man.: Analysis of Tidal Inlets - Sep 87 FY 88 Misc. Report; Preliminary report on Ebb-Tidal Delta Experiment - Jan 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCD-S	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
2	Sand Bypassing System Selection
WORK UNIT NO	
31760	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$210	$ 75	$ 75	$ 55	$ 0	$ 0	$ 0	$ 415

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: The objective of this work unit is to produce an Engineer Manual that will provide the designer with the information and methodology needed to select all feasible alternative bypass designs for a particular problem site at which sand bypassing may be used.

DESCRIPTION: The work will be accomplished through office studies and through studies of working systems and problem sites. The engineering approach will be developed through consideration of site characteristics and the engineering aspects of bypassing systems. Guidance will be developed and presented for characterizing facets of the site and for defining the scope, nature, and extent of the problem. A number of sand bypassing systems will be described including the engineering capabilities and limitations of each. Results of this work will be presented in the form of a procedure which guides a designer through the steps in selecting multiple alternative bypassing systems. The procedure will be explained to FOA personnel in a training seminar to be held after completion of the draft EM.

R&D NEEDS: Currently, no comprehensive source of information or guidance exists on planning and selection procedures for sand bypassing systems. As a result, each sand bypassing project requires input of information from a wide variety of sources and numerous reviews that are costly in terms of both funding and manpower. Development of selection guidance will reduce project costs and time as well as result in a system design chosen with the demanding requirements of a sand bypassing operation in mind. It is estimated that one to two man-years of effort can be saved in the preliminary design phase alone for each sand bypassing project through application of guidelines to be developed by this research. Sand bypassing is necessary at most entrance channels to minimize channel shoaling and maintenance dredging and to assure that beaches adjacent to the harbors or jetties are not eroded due to the presence of coastal structures.

MILESTONES AND FORM OF OUTPUT

Milestone	Date
Draft Installment 1 of EM on Sand Bypassing	APR 85
MP and/or ETL on "Coastal Data Requirements and Analysis For Sand Bypassing System Selection"	JUL 85
Draft Installment 2	DEC 85
MP and/or ETL on "Sand Bypassing Systems-Capabilities and Limitations"	JUN 86
Draft Installment 3	DEC 86
Training Seminar	APR 87

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-002-8	Guidelines for the Design and Construction of Beach Fills	High
23-001-8	Guidelines to Establish a Coastal Sediment Budget	High
23-012-9	Sand Recycling or Nourishment Rates to Establish a Stable Shoreline	High
33-052-2	Comparison of Dredging Alternatives	High
22-009-2	Educator Systems for Sand Bypassing	High

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET ___ OF ___

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
3	*Waves at Entrances*
WORK UNIT NO 31673	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 920	$240	$ 240	$270	$230	$100	$ 0	$2,000

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop methods to predict the wave-current-structure interaction, primarily in the nearshore region near entrances to inlets, harbors, and estuaries.

DESCRIPTION OF WORK: A literature survey and summary of present knowledge on this subject was prepared. Measurements of waves and currents in the nearshore zone will be conducted. A vertically two-dimensional mathematical model for monochromatic wave propagation passing a finite near field involving obstacles and an irregular sea bottom was developed and tested. The corresponding computer program can be used to assess the effect of a reef, bar, trench, floating breakwater, etc. on waves. A wave scattering mathematical model and the corresponding computer program for wave-structure interaction were developed and tested. The model represents three-dimensional effects. An efficient computer program for predicting flow circulation was implemented. A large scale spectral wave-current interaction model and the corresponding program for nearshore waves will be developed and results will be compared with field data. A small scale wave-current-structure interaction model for wave scattering in a finite near field and the corresponding computer program will be developed and results will be compared with field data. Contributions will be made to the Engineer Manual on Coastal Inlet Hydraulics and Sedimentation. Work will be coordinated with other agencies.

R&D NEED: Currents and structures are observed to significantly affect the wave climate, and currents may also be affected by waves. Prediction models would improve the Corps' capability to design for wave-current-structure effects in the areas near entrances to harbors, inlets, or estuaries.

MILESTONES AND FORM OF OUTPUT

FY 85

MP Dispersion relation - Mar 85
CETN Wave Scattering Computer Programs - Jun 85.
Draft IR User's Manual Wave Propagation Model - Sep 85.

FY 86

Draft IR User's Manual Wave Scattering Model - Mar 86.
Draft Report Methodology for Large Scale Model - Sep 86.

FY 87

Draft IR User's Manual Large Scale Model - Mar 87.
Field Experiment - Sep 87.
Draft EM - Sep 87.

FY 88

Workshop on large scale model application Jan 88.
Draft Report Methodology for Small Scale Model - Sep 88.

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-007-9	Predicting Wave Conditions in Shallow Water	High
21-014-0	Wave-Current Interactions	High
21-002-9	Diffraction of Irregular Waves	High
	1983 Coastal Engineering Hydraulic Design Conference, ETL 1110-2-292, FOA needs articulated in paragraphs 226 and 227.	
21-010-0	Wave Setup	High

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY Harbor

PRIORITY	WORK UNIT NO	TITLE
3	31673	Waves at Entrances

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 8	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 920	$240	$ 240	$270	$230	$100	$ 0	$ 2,000

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	FY 89 Draft IR User's Manual Small Scale Model - Mar 89. Draft CETN Simplified Design Curves - Sep 89.

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET 2 OF 2

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Harbor Entrances and Coastal Channels	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
4	Nearshore Waves and Currents
WORK UNIT NO 31672	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY 87	+2 FY 88	+3 FY89	TO COMPLETE	TOTAL
$1505	$ 235	$ 235	$ 230	$ 200	$ 0	$ 0	$ 2,405

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: The objective of this work unit is to develop methods of predicting wave and wind induced currents near the coastline. The mean currents induced by waves and wind stresses in shallow water provide in many instances the major mechanism for the transport of sediment, pollutants and other constituents in shallow coastal waters. The work unit will address wind and wave action and will consider longshore as well as offshore flow. Models for nearshore circulation can be applied to sediment transport models.

DESCRIPTION OF WORK: A literature review will be conducted resulting in a bibliography and state of the art report on nearshore currents which will be supplied via contract. Existing models to calculate nearshore waves and currents will be implemented and verified with field data collected at the FRF. Theories which relate wind velocity to surface wind stress will be tested for a nearshore location using measurements at the FRF. A three-dimensional model to calculate wind driven coastal currents will be implemented. Incorporation of wave driven currents in a three-dimensional model will be investigated.

R&D NEED: For inlet design beach protection, and harbor design, it is essential that the coastal engineer be able to predict sediment transport in the coastal zone. The mean currents induced by waves and wind stresses in shallow water provide in many instances the major mechanism for the transport of sediment, pollutants and other constituents in shallow coastal waters. The currents are poorly predicted at the present time with most predictive models only including wave action. Results will be applicable to the Engineer Manual on Littoral Transport Estimates for Coastal Engineering.

MILESTONES AND FORM OF OUTPUT

FY 85

Draft instructional report on nearshore wave model - Apr 85

FY 86

Draft instructional report on nearshore current model - Apr 86
Workshop on nearshore wave and current models - Apr 86

FY 87

Draft report on the calculation of wind stress in the nearshore region - Apr 87
Draft chapter EM on Littoral Transport Estimates - Sep 87

FY 88

Draft report on the calculation of three-dimensional wind driven currents in the nearshore region Apr 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-004-9	Estimating Along Shore Sand Movements from Incident Waves	High
23-002-8	Guidelines for Design and Construction for Beach files	High
23-003-9	Shore Response to Offshore Dredging	High
23-012-0	Nearshore Current Prediction	High
	1983 Coastal Engineering Hydraulic Design Conference ETL 1110-2-292, FOA needs articulated in paragraphs 244-6.	

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET ___ OF ___

NARRATIVE RATIONALE
COASTAL FLOODING AND STORM PROTECTION

BACKGROUND

Research and development (R&D) in the Coastal Flooding and Storm Protection Program directly supports and is essential to Civil Works planning, design, construction, operation, maintenance, and regulatory activities in the coastal zone requiring a knowledge of these effects. Specific Civil Works missions which depend on and benefit directly from this research are navigation projects in coastal waters, shore protection projects, coastal flood control projects, coastal flood damage prevention projects, and coastal related special and comprehensive projects. A substantial portion of the coastal flooding and storm protection research in the United States is performed by the Corps of Engineers (Corps), and the Corps has almost all the United States laboratory facilities and capability necessary to perform this type of research at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). Consequently, the United States R&D accomplishments in coastal flooding and storm protection are heavily dependent on the Corps.

This research program emphasizes development and advancement of technical methodology and criteria that are directly applicable to field problems concerning coastal flooding and storm protection. An essential and vital portion of the program is directed toward advancement of the understanding of physical processes that govern the characteristics of the waves, currents, and water levels in the coastal zone. This element of the program represents a necessary condition for assuring that future R&D achievements will be both significant and directly applicable to field problems.

Detailed content and emphasis of this program are formulated from input derived from several complementary sources. The user needs system identifies research needs for this and all other Corps research programs. These needs are prioritized through a comprehensive process containing input for all relevant elements of the Corps. CERC reinforces this identification of priorities by obtaining input directly from coastal engineers in District and Division offices, by personal communications and contacts (with the university community, the industrial community, other Federal and state agencies, and foreign centers of expertise), and by liaison team visits to each field office. Additional (or reinforcing) needs are identified by research engineers and scientists of the Corps laboratories and by senior staff engineers of the Office, Chief of Engineers (OCE). Importantly, this research program (and the three other research programs in the Coastal Engineering Area) is overviewed by the Coastal Engineering Research Board (CERB) which advises the Chief of Engineers. The Board is comprised of three Division Engineers and three distinguished civilian members of the coastal engineering community and is chaired by the Deputy Director of Civil Works. The Board uniquely combines and brings to Corps coastal engineering research the managerial vision and foresightedness of general officers responsible for the Corps' coastal missions and the technical understanding of some of the world's foremost coastal engineering authorities. Corps involvement in coastal flooding and storm protection and the consequent requirement for this research is attested to by the more than 100 major commercial harbors, the more than 300 small boat harbors, the nearly 100 beach and shore protection projects, and the 15 coastal flood protection projects it has built.

OBJECTIVES

The objective of this program is to develop technology to reliably predict and describe coastal waves and currents and to accurately predict surges (or water levels) caused by hurricanes and other storms. Specific research outputs are used to develop and advance methodology and criteria that the Corps can apply to plan, design, and construct cost-effective and functionally efficient projects. Regulators can apply this methodology and these criteria to reach sound and defensible decisions in permitting projects whose function and design depend on coastal waves, currents, and water elevations. Similarly, engineers can apply research results from this program to aid in developing more cost-effective and functionally efficient maintenance actions and programs. Advancement in the understanding of the physical processes that govern the characteristics of the waves, water levels, and currents in the coastal zone is a vital underlying objective. These two objectives are complementary, and the long-term success of the program is dependent on the basic underlying directive. Satisfaction of these objectives requires a carefully balanced mix of theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Research in this program searches for relationships, guidelines, and criteria that lead to problem solutions that are practical, functional, and economical. Emphasis is on expressing these relationships, guidelines, and criteria in user products suited to the capabilities and needs of design and construction engineers.

CURRENT RESEARCH AND DEVELOPMENT

Coastal Flooding and Storm Protection research includes theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Currently most emphases and resources are placed on experimental field investigations and data collection and analysis. This research program provides the funding necessary for performing the basic environmental measurements required at CERC's world renowned Field Research Facility (FRF).

Prior Accomplishments

This program has developed complex numerical models that predict water level rises caused by hurricanes and other large storms, that transmit storm surge from the open ocean through inlets into back bays, and that estimate the transformation of waves in shallow water. It has also developed comprehensive data sets from CERC's FRF and Hurricane Surge Data collection network and improved laboratory simulation techniques. In FY 84 workshops were held to present Corps field elements with information on wave groups, shallow-water wave height estimation, and the measurement of wave direction. The shallow-water wave growth model was completed under contract, and testing of the model was begun. A simple refraction/shoaling computer model for directional waves in depth-limited conditions was completed and shallow-water effects were incorporated into the spectral transformation model. A literature review was completed on wave generation over narrow fetches, and two models were selected for comparative evaluation. An Atlantic Remote Sensing Land-Ocean Experiment (ARSLOE) issue of the IEEE journal was printed, a draft of the Engineer Manual titled "Water Levels and Wave Heights for Coastal Design" was substantially completed, and a report summarizing the TMA spectral form and its applications was in publication. A state-of-the-art directional spectral wave generator was delivered and installed during the second quarter of FY 84, and checkout and acceptance testing was accomplished during the third and fourth quarters. A new laboratory data acquisition and control computer (VAX 11/750) was installed and accepted, and directional spectral wave generator control software development was initiated. An International Association of Hydraulic Research spectral wave generation and analysis test experiment was conducted to provide a comparison of wave generation and analysis techniques among seven international hydraulic laboratories. CERC's FRF continued the collection of comprehensive data sets and publication of annual data summaries.

Six technical papers containing results of a US Coast and Geodetic Survey/CERC cooperative study (conducted in October 1982) were presented at the American Society of Civil Engineers (ASCE) International Conference on Coastal Engineering (September 1984). Titles of these papers were: "Longshore Variability of Wave Runup on Natural Beaches," "Beach Foreshore Response to Long Waves in the Surf Zone," "The Role of Suspended Sediment in Shore-Normal Beach Profile Changes," "Cross-Shore Transport of Bimodal Sands in the Surf Zone," "A Coastal Storm Processes Experiment," and "Infragravity Waves on a Barred Profile During a Storm." Conversion of the Coastal, Estuarine, and Lake Circulation three-dimensional (CELC-3D) model to boundary fitted coordinates was substantially completed, and manuals on the stretched Cartesian coordinates version of CELC-3D were published. Over 270 nearshore sites have been preselected in the Gulf of Mexico and the South Atlantic from Brownsville, Texas, to Jacksonville, Florida, for use in mounting hurricane surge gages prior to landfall of major hurricanes. Up to approximately 25 of these sites closest to the predicted landfall location will be instrumented within 96 hr of landfall. These data will be used for testing and verification of numerical hurricane surge models. An air-deployable hurricane surge gage has been developed and field-tested for potential use in collecting surge, wave, and current data offshore during hurricanes. A report entitled "Hurricane Alicia Storm Surge and Wave Data" has been prepared and is in the process of being published. A fourth hardened surge gage has been established at Haulover Inlet near Miami, Florida, in cooperation with the National Ocean Service; a second directional wave/surge gage has been brought on line at Cape Canaveral, Florida, under contract with the University of Florida; and an agreement has been finalized with the National Hurricane Center to deploy up to five surge gages in the South Florida area.

Expected Accomplishments

The draft of an EM titled "Water Levels and Wave Heights for Coastal

Engineering Design" will be completed. Workshops for Corps personnel will be held on modeling shallow-water waves and on radar capabilities for waves. The shallow-water wave growth model will be documented and used to obtain shallow-water design curves. The simple refraction shoaling model for depth-limited conditions will be documented, and work will continue on automatic radar image analysis and on wave generation over narrow fetches. Adaptation of the shallow-water wave growth model for hurricane wind fields will begin, and work will continue on shallow-water height distributions. Directional spectral wave generator characteristics will be defined and quantified, and instruction reports for unidirectional and directional wave spectra will be published. The addition of this capability will greatly enhance CERC's ability to accurately reproduce "real world" wave conditions in laboratory test programs. Routine data collection will be continued at the FRF with monthly publication of results and preparation of annual data summaries. A revised FRF User's Guide will be published, and cooperative agreements with other government agencies, universities, etc., will continue. Development and documentation of the numerical Coastal Modeling System will continue. Work will be initiated on adding major model capability for constituent transport, wave-induced currents, and boundary fitted coordinates. A state of preparedness for hurricane surge data collection will be maintained. Should a hurricane strike the Gulf of Mexico or South Atlantic coast of Florida, the CERC field team will respond to install surge gages at preselected sites along the predicted path. These data, along with those from fixed offshore gages, will be used to better quantify the accuracy and reliability of numerical storm surge models.

Benefits

Development of more accurate methods for estimating waves (all waves, including wind-waves, tides, storm), surges, tsunamis, etc., in shallow water is essential for more reliable and cost effective engineering of every coastal project. The importance of a better and more comprehensive understanding of waves, currents, and water levels cannot be overemphasized. Waves are the dominant forcing function for the design of all coastal projects. Consequently, advancement in our understanding of waves and storm surges is a necessary prerequisite and a key ingredient to improvements in the three other research programs (Harbor Entrances and Coastal Channels, Shore Protection and Restoration, and Coastal Structure Evaluation and Design) comprising the Coastal Engineering Area. Research results from this program are expected to benefit not only the Corps but also the Navy and other organizations that construct and maintain facilities in shallow water or operate there. Preliminary research results have suggested that current methods for estimating design waves in shallow water are overly conservative for many situations and that lower design wave heights may be reliably estimated. Should future research confirm this indication, the potential for dollar savings in coastal projects is at least millions of dollars annually. The basic field measurements collected under this program at the FRF are necessary to the operation of the FRF and represent the only sustained measurement program of this type in the United States. The storm surge data collection effort is unique and essential to the improvement of storm surge models. Collection of data from a hurricane will represent the only high quality storm surge data set in existence. These two measurement programs have provided and will provide extremely rare and valuable data on which present technical methodologies are to be judged and future methodologies will be based. These data are particularly important because the engineering and scientific communities' ability to numerically and/or physically model basic wave, current, and storm surge phenomena necessary for reliable planning, design, and construction of coastal projects has in many cases exceeded the communities' ability to check or validate these models for a range of realistic conditions because of a lack of basic prototype data.

FUTURE RESEARCH

Research in coastal flooding and storm protection will continue to address problems identified by the user needs system reinforced by input from coastal engineers in the field offices and OCE, the CERC research staff, and the CERB. Long-range planning is based partly on anticipation of these needs and largely on input and advice from the CERB. Past laboratory research in coastal flooding and storm protection has given the Corps reasonably good qualitative understandings and conceptual models of the physical processes involving waves, water levels, and currents in the coastal zone. Based on these understandings and models and judiciously selected field observations, the Corps has developed what could be termed first generation design capability in this area. This is somewhat of an oversimplification. Research, both in the laboratory and in the field, has concurrently produced some quantitative models and has added sophistication to some design capabilities. But, even though sharp delineation is lacking, it is important to note that research in coastal flooding and storm protection has changed direction and emphasis. A larger proportion of the research is now field oriented, and it concentrates on increasing the sophistication of our understanding of the physical processes of nearshore waves, currents, and water levels. Future research will focus heavily on quantification of conceptual models. This research will produce a second generation design capability for projects related to coastal flooding and storm protection and will form the necessary basis for producing a second generation design capability in all coastal projects (since design conditions for all projects have a dependence on waves as the basic forcing function for the design conditions). As an illustrative example, past research developed understandings and models (somewhat quantified) of solitary, simple waves; first generation design capability uses such waves. Future research will develop quantified models of complex wave spectra; second generation design capability will use wave spectra. Future research in coastal flooding and storm protection will develop models to accurately transform waves as they propagate from deep to shallow water to reliably predict the water level in back bays and lagoons resulting from storm surge transmissions through inlets and over barrier islands and to better quantify the characteristics of storm wave spectra. These models will provide the Corps with the key basic ingredient necessary to greatly improve its capability to determine the effects of waves on navigation structures, to determine the effects of coastal flooding, to determine the effects of structures on adjacent shores and beaches, to predict shoreline erosion and/or accretion, to determine the potential shoaling rates of coastal navigation channels, to design coastal flood protection, and to optimize the design of structures in the coastal zone. The overall result will be more functionally efficient and more economical projects.

COORDINATION

A number of mechanisms in place and a number of ongoing activities ensure coordination of the coastal flooding and storm protection research within the Corps, within government, and within the overall coastal engineering community. One of the most important coordination requirements is that with the other three research programs in the Coastal Engineering Area. Formal coordination is achieved through an annual technical review of work units in the entire Coastal Engineering Area. This review is attended by all principal investigators in the Coastal Engineering Area and is chaired by the Chief of CERC. In addition to this, formal quarterly reviews of milestone achievements and fiscal status are held for all programs in the Coastal Engineering Area. Continued technical coordination is facilitated between programs by participation of most principal investigators on interdisciplinary project teams in more than one program. Certain coordination mechanisms and activities (e.g., program reviews, Research and Development Review Board reviews, Lab Commanders' Conferences, and publication of programs) are common to all Corps research programs. Certain others are unique. The CERB meets semiannually, and its meetings provide a forum in which the program is discussed by and with responsible Corps coastal engineers. The presence of leading members of the coastal engineering community from outside the Federal government on the Board relates the Corps' program to that of the overall community. CERC liaison representatives visit each coastal Division and District and discuss the program. Division representatives are invited to technical program reviews conducted at CERC.

Continuing informal contact is maintained with Federal, state, and academic organizations involved in coastal flooding and storm protection research. Particularly close relationships are maintained with key personnel in complementary research areas in various offices of the National Oceanic and Atmospheric Administration and the US Navy. A CERC representative attends the annual Navy Oceanographic Program Review. Joint projects with other agencies and organizations are undertaken whenever there is a mutual benefit, especially experimental studies at our FRF. In fiscal year 1983, 12 universities and 11 Federal agencies sent personnel to the FRF to participate in experiments. The Chief of CERC is the present Corps liaison representative to the Marine Board, National Research Council, National Academy of Engineering. This formal position is of immense benefit in assuring excellent coordination of this and other research programs in the Coastal Engineering Area with the industrial, academic, and Federal research communities. Lectures concerning this research program are given by the Chief and key senior staff members of CERC at universities and at professional meetings throughout the United States (and worldwide when possible). Staff members of CERC are heavily involved in activities and programs of all pertinent professional societies. A number of others serve as members (or chairmen) of various technical committees of various coastal engineering related professional societies. The following table provides a funding summary for the Coastal Floodinig and Storm Protection Programs.

COASTAL FLOODING AND STORM PROTECTION PROGRAM

FUNDING SUMMARY

Priority	Work Unit Number	Work Unit Title	Performing Laboratory	FY Funding Thousands of Dollars CFY FY 85	FY Funding Thousands of Dollars BFY FY 86
1	31592	Wave Estimation for Design	WES	270	280
2	31762	Laboratory Simulation of Spectral and Directional Spectral Waves	WES	290	250
3	31537	Field Research Facility Measurements and Analysis	WES	910	925
4	31675	Developing, Updating, and Maintaining Coastal Numerical Models for Field Use	WES	100	100
5	31662	Hurricane Surge Prototype Data Collection	WES	250	290
6	32262	Nearshore Directional Wave Gage Technology	WES	0	75
			Total	1,820	1,920

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

OGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

IORITY	TITLE
1	Wave Estimation for Design
RK UNIT NO: 31592	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$3824	$270	$280	$280	$200	$95	$50	$4,999

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To improve the Corps' capability to estimate wave conditions for use in design, construction, operation and maintenance of coastal projects, and to provide the field offices with the necessary design aids to make these estimates.

DESCRIPTION OF WORK: Develop and/or improve numerical models for combined refraction and diffraction over a large irregular area, refraction and diffraction in a small area particularly near a structure, directional spectral estimation for complex fetch, irregular bathymetry, and tropical storms; evaluate models by comparison with measurements from Field Research Facility and Field Data Collection Program; improve techniques for analyzing field wave data to identify direction and nonlinear features such as grouping and nonsinusoidal wave profiles; apply improved information to interpretation of hindcast spectra and to coastal design.

R&D NEED: To obtain accurate estimates from hindcasts and measurements of all aspects of shallow water wave conditions which are important in engineering work and to understand how the estimates are best used in design, construction, operation and maintenance of coastal projects. To develop Engineering Manual for Coastal Wave Heights and Water Levels.

MILESTONES AND FORM OF OUTPUT

FY 85

Draft EM Water Levels and Wave Heights - Oct 84; TR-TMA Spectral Summary - Dec 84; Workshop Radar Capabilities for Waves - Jan 85; Workshop Modeling Shallow Water Waves - Jan 85; Draft CETN Depth-Limited Propagation Model - Jul 85; Draft IR Shallow Water Wave Growth Model - Aug 85.

FY 86

Draft CETN Automatic Analysis of Radar Imagery - Dec 85; Draft IR Hurricane Wave Model - May 86; Draft TR Wave Height Distributions (possible ETL) - Sep 86; DUCK '86 Experiment - Sep 86.

FY 87

Workshop Hurricane Waves - Jan 87; Workshop Narrow Fetches - Jan 87; Draft CETN Narrow Fetch Model - Mar 87; Draft CETN Hurricane Wave Model - Mar 87; Draft TR Narrow Fetch Wave Generation - Jun 87; Draft TR Shallow Water Swell Spectra -

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-002-9	Diffraction of Irregular Waves	High
21-006-9	Wave Direction	High
21-007-9	Predicting Wave Conditions in Shallow Water	High
21-008-9	Wave Generation in Restricted Fetches	High
21-001-8	Wave Runup and Overtopping	High
21-013-0	Wave Data Analysis Techniques for Design	High
23-004-9	Estimating Alongshore Sand Movements from Incident Waves	High
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures on Shorelines	High
24-008-9	Improved Rubble-Mound Design Criteria	High
24-014-0	Wave Forces on Nearshore Structures	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(E R 70-1-11)

RCS: DAEN-RD-5

ROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCR-O	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Wave Estimation for Design
WORK UNIT NO: 31592	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY86	+1 FY87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$3824	$270	$280	$280	$200	$95	$50	$4,999

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	Aug 87; Shallow Water Wave Growth Experiment - Sep 87. <u>FY 88</u> Draft CETN Shallow Water Design Curves - Apr 88; Draft TR Fetch and Duration Limited Shallow Water Wave Spectra - May 88; Draft Revisions for EM Water Levels and Wave Heights - Aug 88; Draft Revisions for ETL Sheltered Water Wave Characteristics - Sep 88. <u>FY 89</u> Draft TR - Surf Zone Wave Height Distributions - Jul 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
	1983 Coastal Engineering Hydraulic Design Conference, ETL 1110-2-292: FOA needs articulated in paragraphs 62 and 90.	

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCW-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
2	321 31762	Laboratory Simulation of Spectral and Directional Spectral Waves

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 465	$ 290	$ 250	$ 200	$ 125	$	$ 0	$ 1330

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: Evaluate the accuracy and reliability of laboratory simulation of unidirectional and directional wave spectra and quantify this accuracy and reliability.

DESCRIPTION OF WORK:

1. Evaluate and quantify the accuracy and reliability of laboratory simulation of unidirectional wave spectra and unidirectional spectral wave transformation for constant depth and a range of typical bottom slopes for normal incidence.

2. Evaluate and quantify the accuracy and reliability of laboratory simulation of directional spectral wave transformation over a sloping bottom at various incident wave angles for unidirectional incident spectra.

3. Evaluate and quantify the accuracy and reliability of laboratory simulation of directional spectral wave generation.

R&D NEED: Accurate and reliable laboratory simulation of the directional distribution of wave energy is necessary to more properly represent prototype wave height distributions and longshore currents. Development of the capability to quantify the accuracy and reliability of spectral and directional spectral wave energies in experimental studies will represent an extremely significant and important advance in the state-of-the-art. Directional spectral wave studies are expected to have a profound influence over a broad range of coastal engineering site-specific studies as well as research investigations. Simulation of wave

MILESTONES AND FORM OF OUTPUT

FY85

Instructional Report Unidirectional Spectra - Jan 85

FY86

Instructional Report Directional Spectra - Jan 86

FY87

Instructional Report Directional Analysis of Model Wave . ta - Jun 87

FY88

Instructional Report Modification of Directional Wave Spectra in the Neashore Zone - Sep 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-001-8	Wave Runup and Overtopping	High
21-002-9	Diffraction of Irregular Waves	High
23-016-9	Erosion Due to Storms	High
21-004-9	Offshore Breakwaters for Coastal Protection	High
21-014-0	Wave Current Interaction	High
23-003-9	Shore Response to Offshore Dredging	High
23-005-9	Development of Modeling Techniques to Advance State-of-the-Art for Quantifying Hydraulic-Sediment Interaction	High
23-008-9	Seaward Limit of Significant Sand Transport by Waves	High
23-009-9	Littoral Transport Testing Procedures	High
24-006-9	Weir Jetty Design for Inlet Maintenance and Stabilization	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCW-R	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
2	321 31762	Laboratory Simulation of Spectral and Directional Spectral Waves

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 465	$ 290	$ 250	$ 200	$ 125	$	$ 0	$ 1330

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
spectra in models must be evaluated for conformance with prototype spectra, particularly with regard to length of record and frequency lines required to insure adequate wave height distribution and to obtain spectrally significant estimates of wave test results. Effects of differing wave trains with the same power spectra, as well as spectral transformation as the waves propagate, also must be determined. Most experimental studies of harbors, breakwaters, tidal inlets, sediment transport, sand bypassing, moored ship response, navigation at ocean entrances, etc. will benefit substantially from the development of this capability.	

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

:RAM TITLE		ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection		WESCR-F	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

'RITY	TITLE
3	Field Research Facility Measurements and Analysis
'K UNIT NO	
31537	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$5566	$ 910	$ 950	$ 1050	$1120	$1230	$ Cont.	$ Cont.

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

Objectives: Measure, record, and analyze oceanographic, meteorologic, and engineering data in the vicinity of the Field Research Facility (FRF) at Duck, NC; assess the effects of the FRF pier on waves, currents, and the nearshore bottom.

Description of Work: Wave gages, anemometers, current meters, tide gages, and water quality sensors are installed, operated and recorded at the FRF. The data are made available to other work units underway at CERC, the Corps of Engineers' Field Data Collection Program, and local Corps' Districts. Seasonal and spatial variability of factors influencing coastal design will be quantified and interactions between selected oceanographic forces and the effects of these forces on beach and nearshore processes will be determined.

Why R&D is Needed: The data will be used to verify numerical and physical models of waves, currents and sediment transport; pier effects will be assessed. To obtain high-quality wave, water level, and beach data, including during storms, to supplement CERC's laboratory data for the solution of coastal engineering problems that face various Corps' Districts and Divisions.

MILESTONES AND FORM OF OUTPUT

1981 FRF Annual Data Summary (Oct 84)

FRF User's Guide (Nov 84)

1982 FRF Annual Data Summary (Jun 85)

1983 FRF Annual Data Summary (Sep 85)

FRF Baylor gage comparison (Sep 85)

1984 FRF Annual Data Summary (Dec 85)

Pressure Response Evaluation (Sep 86)

1985 FRF Annual Data Summary (Dec 86)

Wind shear measurement results during Exp. "GALE" (Sep 86)

1986 FRF Annual Data Summary (Dec 87)

1987 FRF Annual Data Summary (Dec 88)

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-004-9	Estimating Longshore Sand Movement from Incident Waves	High
23-007-9	Littoral Data Collection Methods and Their Engineering Application	High
21-012-0	Nearshore Current Prediction	High
21-006-9	Wave Direction	High

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding & Storm Protection	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY: 4

WORK UNIT NO: 321 31675

TITLE: Developing, Updating, and Maintaining Coastal Numerical Models for Field Use

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$245	$100	$100	$150	$130	$200	$720	$1,695

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop new or improve and maintain existing coastal numerical models for field office use.

DESCRIPTION OF WORK: Various numerical coastal models (for both long- and short-period wave behavior simulation) are currently used at WES and to some extent by field offices. A major effort is being undertaken to consolidate such models into a system which would simplify their use, reduce learning and setup costs, and provide a common source for CE use. Topics to be addressed include efficient variable grid spacing (such as boundary fitted coordinates), pre- and post-processing routines, and improved formulations for meteorological modeling, boundary conditions, friction and advection representations. Models to be implemented into the proposed system include 2- and 3-dimensional long-wave models. The model system will be documented and maintained for laboratory and field office use.

R&D NEEDS: This research is necessary to continue to provide accurate, reliable, and economical state-of-the-art numerical models for simulating wave phenomena such as tidal circulation, storm surge, tsunami propagation, and associated transport processes. The Committee on Tidal Hydraulics in an evaluation of storm surge models has recommended that such models used by CE be maintained and improved. Use of these numerical models by districts and divisions is more economical than physical models for studying certain classes of wave problems, and they should be made available with good documentation for their use.

MILESTONES AND FORM OF OUTPUT

Workshop on system/WIFM & SPH implementations - Sep 85

System Documentation - User notebook & online instructions - Sep 85

CETN - describing the WIFM & SPH technology available in CMS and suggested areas of application - Dec 85

Workshop on system/WIFM, SPH, & CURRENT (wave-induced currents) implementations - Sep 86

System documentation - Update of user notebook & online instructions - Sep 86

CETN - Update of previous information to include CURRENT implementation - Dec 86

-continued-

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-02009	Improvements and Maintenance of Generalized Numerical hydrodynamic models	High
23-005-9	Development of Modeling Technique to Advance State-of-the-Art for Quantifying Hydraulic-Sediment Interaction	High
24-005-9	Numerical Modeling to Evaluate Effects .. Coastal Structures on Shorelines	High
22-006-0	Inlet Hydraulics	High
23-016-9	Erosion Due to Storms	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding & Storm Protection	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO.	TITLE
4	321 31675	Developing, Updating, and Maintaining Coastal Numerical Models for Field Use

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 245	$ 100	$ 100	$ 150	$ 180	$ 200	$ 720	$1,695

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	Workshop on updated system contents SAL (salinity transport) & documentation - Sep 87 Workshop on updated system contents CELC3D (3-D) & documentation - Sep 88 Workshop on updated system contents & documentation - Sep 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Waves and Coastal Flooding (Coastal Flooding and Storm Protection)	WESCD-P	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY	
PRIORITY: 5	TITLE: Hurricane Surge Prototype Data Collection
WORK UNIT NO: 321-31662	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$1590	$ 250	$ 290	$ 255	$ 270	$ 205	$	$2860

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To collect a comprehensive data set to better define the coastal and inland water elevation time histories, high-water marks, nearshore wave climate and water velocity fields associated with tropical cyclones.

DESCRIPTION OF WORK: The procedure involves a cooperative effort of the Corps of Engineers (CE), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey and the U.S. Nuclear Regulatory Commission along with various academic institutions. A group of recognized consultants has been established to aid in planning and technical decisions concerned with the project. The CE role in this effort is limited primarily to acquisition of hydrodynamic data, i.e., surge, wave and marine flooding. The National Hurricane Center, through its Project Strike, has assumed primary responsibility for acquisition of the meteorological data associated with landfalling tropical storms. The efforts of both WES and the Project Strike group are closely coordinated.

The basic plan includes the following elements:

a. Deployment of approximately 25 portable instrument packages at preselected sites some 48 to 24 hrs prior to the estimated time of landfall of a threatening storm or hurricane. Approximately 270 sites have been selected in the coastal areas of Texas, Louisiana, Mississippi, Alabama, and Florida.

MILESTONES AND FORM OF OUTPUT

Milestone	Date
Report on Hurricane Induced Forerunner Surge (Unscheduled Milestone)	Mar 85
Report on Assessment of Global Positioning System for Vertical Control	Sep 85
Information Available for Update of EM1110-2-3300 in	Dec 85
Data Reports on Hurricanes	As Available

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-019-0	Hurricane Surge Prototype Data Collection	High
23-016-9	Erosion Due to Storms	High
21-001-8	Wave Runup and Overtopping	High
22-008-4	Planning of Design Considerations for Deep Draft Navigation Channels	High
24-014-0	Wave Forces on Nearshore Structures	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Waves and Coastal Flooding (Coastal Flooding and Storm Protection)	WESCD-P	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
5	321-31662	Hurricane Surge Prototype Data Collection

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$ 1590	$ 250	$ 290	$ 255	$ 270	$ 205	$ 0	$ 2860

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	MISSION PROBLEMS ADDRESSED: NO.	TITLE	FIELD RANK

b. Establishment of semipermanent surge/wave gage sites in remote or inaccessible areas. Seventeen of these sites are currently in operation either directly by CE, by interagency agreement or by contract. They are distributed from Brownsville, TX, to Jacksonville, FL.

c. Interagency performance of aerial overlights poststorm and, funding permitting, also prestorm.

d. Dissemination of acquired data.

R&D NEED: The collection of storm event data (high-water elevations, inland and coastal water-level time histories, and inundation extent) associated with tropical storms and hurricanes is of paramount importance to the support and evaluation of a number of Corps of Engineer Missions. Technically sound and economic design and evaluation of many coastal projects are dependent upon estimates of storm surge levels to be expected from hurricanes of given size and intensity. Numerical models developed for this purpose provide apparently reasonable estimates. The estimates, however, may differ among themselves to a significant degree. The introduction of finite element and boundary fitted coordinate models permit a more realistic representation of land/water boundaries on a smaller scale than is possible with the previously developed rectangular grid models. These more realistic models have emphasized the need for high-quality prototype data obtained in a well planned and coherent manner and on scales similar to those of the models. The data are necessary to quantitatively evaluate various features of these models as well as the models themselves. Moreover, these data will contribute to a better understanding of coastal processes

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY (ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Waves and Coastal Flooding (Coastal Flooding and Storm Protection)	WESCD-P	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
5	321-31662	Hurricane Surge Prototype Data Collection

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$1590	$250	$290	$255	$270	$205	$0	$2860

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	MISSION PROBLEMS ADDRESSED: NO.	TITLE	FIELD RANK
(e.g., nearshore sediment transport, beach erosion, wave setup) during periods of abnormally severe wave activity and high water elevations.				

ENG FORM 4413-R, May 81 (Proponent: DAEN-R) SHEET 3 OF 3

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCD-P	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
6	Nearshore Directional Wave Gage Technology
WORK UNIT NO: 32262	

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 0	$ 0	$ 75	$ 150	$ 225	$ 175	$	$ 625

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop new directional wave measurement technology which will be easily deployable, highly survivable and reliable, have improved accuracy and resolution, more frequent sampling, and reduced cost of operation.

DESCRIPTION OF WORK: Work will be done investigating new methods of deployment and recovery including diverless operations. Instrument mounting arrangements which protect instruments from trawling and storm induced wave forces will be developed. Advanced microcomputer electronics will be developed to allow in situ analysis of data, solid state recording, and advanced forms of data transmission. Alternative instrumentation for measuring directional waves in shallow water shall be investigated, including advanced arrays and acoustic doppler techniques. Advanced random directional sea simulation techniques will be developed and applied to the analysis of gage performance during the design optimization phase. New data analysis procedures shall be developed to allow better estimates of directional spectra to be obtained from new and existing instruments.

R&D NEED: Improved solutions to both applied and research problems in coastal investigating new methods of deployment and recovery including engineering are dependent on accurate field measurement of the directional spectra of ocean waves. Beach erosion and sediment transport problems are so dependent upon directional wave information that it is unlikely that further advances in this difficult field will be possible before improved directional wave information is available. Design of coastal structures, ports, and channels requires accurate information on the directional characteristics of waves. Inadequate directional wave information can, in the best case, lead to project overdesign and, in the worst case, to project

MILESTONES AND FORM OF OUTPUT

FY-86

Construct Prototype of Short Baseline Slope Array -Sep 86

FY-87

Field Evaluation of Short Baseline Slope Array at Duck 86 Experiment -Oct 86

Draft Technical Report - "Simulation Techniques for Analysis of Directional Wave Gage Response" -Dec 86

FY-88

Draft Technical Report - "Field Intercomparison of In Situ Directional Wave Gage Arrays" -Dec 87

Draft Design Report - Advanced Directional Wage Gage -Sep 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
21-006-9	Wave Direction	High
21-007-9	Predicting Wave Conditions in Shallow Water	High
21-012-0	Nearshore Current Prediction	High
22-008-9	Planning of Design Considerations for Deep Draft Navigation Channels	High
24-014-0	Wave Forces on Nearshore Structures	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Coastal Flooding and Storm Protection	WESCD-P	85-03-26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
6	32262	Nearshore Directional Wave Gage Technology

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY86	+1 FY 87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$ 0	$0	$75	$150	$225	$175	$	$ 625

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
failure. Present directional wave measurement technology is expensive and susceptible to failure due to environmental extremes and commercial *fishing activity. Technology presently used by the* Corps for site specific and routine monitoring has extremely limited directional resolution. Technology resulting from the work unit will be transferred to the Districts and cooperating researchers via reports, technical notes, field demonstrations, and the availability of working prototype instrumentation.	FY-89 Field Test of Prototype Advanced Directional Wave Gage -Oct 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

ENG FORM 4413-R, May 81

(Proponent: DAEN-RD) SHEET ___ OF ___

NARRATIVE RATIONALE
SHORE PROTECTION AND RESTORATION

BACKGROUND

Research and development in the Shore Protection and Restoration Program directly supports and is essential to civil works planning, design, construction, operation, maintenance, and regulatory activities in the coastal zone requiring a knowledge of these effects. Specific civil works missions which depend on and benefit directly from this research are shore protection projects, navigation projects in coastal waters, coastal flood control projects, coastal flood damage prevention projects, and coastal related special and comprehensive projects. Almost all of the shore protection and restoration research in the United States is performed by the Corps of Engineers (Corps), and the Corps has practically all the United States laboratory facilities and capability necessary to perform this research at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Consequently, the United States' research and development accomplishments in shore protection and restoration are almost entirely dependent on the Corps.

This research program emphasizes development and advancement of technical methodology and criteria that are directly applicable to field problems concerning shore protection and restoration. An essential and vital portion of the program is directed toward advancement of the understanding of physical processes responsible for the dynamics of sediment transport in the coastal zone. This element of the program represents a necessary condition for assuring that future research and development achievements will be both significant and directly applicable to field problems.

Detailed content and emphases of this program are formulated from input derived from several complementary sources. The user needs system identifies research needs for this and all other Corps research programs. These needs are prioritized through a comprehensive process containing input for all relevant elements of the Corps. CERC reinforces this identification of priorities by obtaining input directly from coastal engineers in District and Division offices, by personal communications and contacts (with the university community, the industrial community, other Federal and state agencies, and foreign centers of expertise), and by annual liaison team visits to each field office. Additional (or reinforcing) needs are identified by research engineers and scientists of the Corps laboratories and by senior staff engineers of the Office, Chief of Engineers (OCE). Importantly, this research program (and the three other research programs in the Coastal Engineering Area) is overviewed by the Coastal Engineering Research Board (CERB) which advises the Chief of Engineers. CERB is comprised of three Division Engineers and three distinguished civilian members of the coastal engineering community and is chaired by the Deputy Director of Civil Works. CERB uniquely combines and brings to Corps coastal engineering research the managerial vision and foresightedness of general officers responsible for the Corps' coastal missions and the technical understanding of some of the world's foremost coastal engineering authorities.

Corps involvement in shore protection and restoration and the consequent requirement for this research is attested to by the nearly 100 beach and shore protection projects and the 15 coastal flood protection projects it has built. In 1984, the Corps had over 15 shore and beach protection projects, 10 flood damage prevention projects, and 3 special projects in various stages of active planning and design, to which output from this research program is directly related. In addition, results from this research program complement the other three research programs in the Coastal Engineering Area. Consequently, there is definite relation of research results from this program to the hundreds of harbor projects the Corps has built and the over 50 harbor projects now in an active planning and design phase. This convincingly foretells continued involvement and need for the future products of this research and development program.

OBJECTIVES

The objective of this program is to develop the technology necessary to reliably determine the patterns and amounts of sediment movement in the coastal zone and to protect eroded beaches and shores. Specific research outputs are used to develop and advance methodology and criteria that the Corps can apply to plan, design, and construct, cost-effective and functionally efficient projects. Regulators can apply this methodology and these criteria to reach sound and defensible decisions in permitting projects whose function and design are related to or may impact on shore protection and restoration projects. Similarly, engineers can apply research results from this program to aid in developing more cost-effective and functionally efficient maintenance actions and programs. Advancement in the understanding of the physical processes that govern the short-term and long-term dynamics of sediment transport in the coastal zone and on the beaches and shores is a vital underlying objective. These two objectives are complementary, and the long-term success of the program is dependent on the basic underlying directive. Satisfaction of these objectives requires a carefully balanced mix of theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Research in this program searches for relationships, guidelines, and criteria that lead to problem solutions that are practical, functional, and economical. Emphasis is on expressing these relationships, guidelines, and criteria in user products suited to the capabilities and needs of design and construction engineers.

CURRENT RESEARCH AND DEVELOPMENT

Shore protection and restoration research includes theoretical and numerical studies, experimental laboratory and field investigations, and prototype data collection and analysis. Currently there is a balanced mix of each type of research with slightly more emphasis placed on experimental field investigations and data collection and analysis. All the research is assigned to CERC.

Prior Accomplishments

Historical (since 1850) shoreline change maps for the Delmarva Peninsula of New Jersey were completed under a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Survey (NOS). Field data efforts concerning the geologic history of barrier islands were completed and laboratory analysis of the data was initiated. Data collection and reduction were completed for the sediment source study conducted at St. Lucie Inlet, Florida. Draft reports were prepared on cape formation and the depositional history and predicted morphological changes of the Virginia barrier islands. A report was completed which evaluates a method developed in Europe for estimating storm erosion. Also a user's manual for the Interactive Survey Reduction Program was completed.

A wave propagation numerical model was developed that determines combined refraction-diffraction of waves over a complex bathymetry. Work was completed and a technical report published on a model of wave breaking and decay across the surf zone. Reports were published on handheld programmable calculator codes for wave forecasting relationships and statistics of visual wave observations. A small diver-operated coring device was developed for use in the surf zone. The Currituck Phase II experiment, which involved depositing dredged material in the nearshore region using a split-hull dredge, was analyzed and results were presented in a draft report. Movable-bed model modeling guidance was provided in a draft report of two-dimensional movable-bed flume tests.

Expected Accomplishments

During fiscal year 1985 (FY 85), reports will be published presenting shoreline change maps and analyses for South Carolina and New Jersey. A geomorphic assessment of Assateague Island and Ocean City Inlet will be published. Draft reports will be completed on sediment variability in barrier island environments, marsh sedimentation, and catastrophic event (i.e. hurricane) deposition. A report will be completed on the first 4 years of data collection by the Coastal Research Amphibious Buggy. Technical reports will be published on sand transport distribution over weir jetties, statistics of energy flux, and visual wave observations. Postfill conditions at Delray, Florida, will be monitored to assess whether compaction contributes to apparent losses of fill material. An undistorted three dimensional model of Santa Barbara Harbor will be constructed to begin tests to quantitatively predict harbor shoaling rates and beach changes. Development and tests of a numerical method to account for wave diffraction due to structures will be completed. A shoreline response numerical model developed in Japan will be tested for field use. The regional coastal processes numerical modeling system will be further developed by converting the wave propagation model to curvilinear coordinates, integration of a long wave model into the system, and development of a regional sediment transport model.

Benefits

Development of more quantitative methods for estimating the short-term and long-term dynamics of sediment in the coastal zone is absolutely essential to improving the functional design and minimizing the cost of shore protection and restoration projects and for reliably evaluating effects of coastal

AD-A159 991 PROCEEDINGS OF THE MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD (43R..(U) COASTAL ENGINEERING RESEARCH CENTER VICKSBURG MS R W WHALIN AUG 85 6/6

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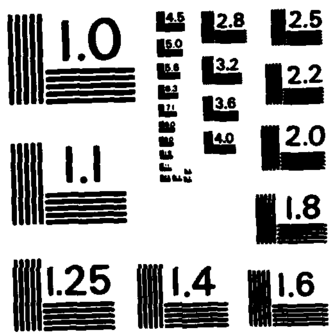

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

navigation projects on adjacent shores and beaches. A majority of the US population lives within a short driving distance of shores and beaches, and results from this research program would provide benefits enjoyed by a majority of the US population. In past experiences, some restored and nourished beaches have required renourishment much sooner than expected, causing annual costs for such projects to exceed expectations. As future results from this research program become available, such cases will become more and more rare. The group of numerical models being developed, improved, and verified will provide a more sound basis for design of future projects. As the understanding of barrier island behavior advances and as predictive models of barrier islands come on-line, more sound decisions concerning the long-term use and protection of these valuable resources can be made. This research program benefits substantially from research progress in the understanding of waves and wave transformation under the Coastal Flooding and Storm Protection Program. Likewise research results from this program provide a valuable input to both the Coastal Structure Design and Evaluation Program and the Harbor Entrances and Coastal Channels Program since an improved understanding of the dynamics of sediment in the coastal zone is basic to improving design criteria for coastal structures, harbor entrances, and coastal channels. A tremendous benefit to more sound coastal zone planning and management will ensue when output from the new work unit directed toward development of a regional coastal processes numerical model is available. This will enable the evaluation of various projects' effects on the regional coastal processes, a task which cannot now be accomplished.

FUTURE RESEARCH

Research in shore protection and restoration will continue to address problems identified by the user needs system reinforced by input from coastal engineers in the field offices and OCE, CERC research staff, and CERB. Long-range planning is based partly on anticipation of these needs and largely on input and advice from CERB. Past laboratory research in shore protection and restoration has given the Corps reasonably good qualitative understandings and conceptual models of the physical processes involving sediment patterns and movement in the coastal zone. Based on these understandings and models and judiciously selected field observations, the Corps has developed what could be termed first generation design capability in this area. It is important to note that research in shore protection and restoration has changed direction and emphasis in the past few years. A larger proportion of the research is now numerically oriented and is strongly supplemented by field experiments. The research concentrates on increasing the sophistication of our understanding of the physical processes responsible for both the short-term and long-term dynamics of coastal sediments.

Future research will focus heavily on quantification of numerical models to better estimate the dynamics of coastal sediments. This research will produce a second generation design capability for projects related to shore protection and restoration. This second generation design capability will be based on reliable directional spectral wave statistics and will enable the designer to not only base his design on mean annual upcoast, downcoast, and net transport rates but also to analyze the probability that these rates will be exceeded and to know the risk that is involved with any design transport rate selected. Future research in shore protection and restoration will increase the understanding of sediment transport processes along US open coasts, as well as in tidal inlets and back bay marsh areas where ship navigation channels, ports and harbors, and other engineering works may be present. The level of quantitative knowledge of how coastal sediments interact with waves, tides, and sea level elevation change on time scales ranging from days, to seasons, to project lives of 50 to 100 years, will be increased.

This information will aid in design and construction of engineering works and help to better manage coastal resources in future years. Also this information is vital for man to be able to live near and utilize some coastal environments without harming natural processes or creating unacceptable risks. In specific terms, variables needed to compute sediment budgets along barrier island coasts and at inlets between barriers will be refined. Improved numerical models, verified with data from several field sites, will be available to predict the effects of various engineering structures on littoral processes. Designs for offshore breakwaters and beach nourishment projects will be improved to reduce overall costs and improve project performance. Results from storm erosion studies at field sites will yield reliable numerical models useful to more accurately predict future erosion trends. Laboratory physical models of coastal projects will be improved and verified with more quantitative and reliable field data to ensure that they have the capacity to give reliable information on performance of shore protection and restoration projects. Overall, the elements in this program will benefit the Corps in making its projects more functionally and economically efficient, and it will aid in evaluating projects from outside sources that require OCE approval and/or permits.

COORDINATION

A number of mechanisms in place and a number of ongoing activities ensure coordination of the shore protection and restoration research within the Corps, within government, and within the overall coastal engineering community. One of the most important coordination requirements is that with the other three research programs in the Coastal Engineering Area. Formal coordination is achieved through an annual technical review of work units in the entire Coastal Engineering Area. This review is attended by all principal investigators in the Coastal Engineering Area and is chaired by the Chief, CERC. In addition to this, formal quarterly reviews of milestone achievements and fiscal status are held for all programs in the Coastal Engineering Area. Continued technical coordination is facilitated between programs by participation of most principal investigators on interdisciplinary project teams in more than one program. Certain of these mechanisms and activities (e.g., program reviews, Research and Development Review Board reviews, Laboratory Commanders' Conferences, and annual publication of programs) are common to all Corps research programs. Certain others are unique. CERB meets semiannually, and its meetings are a forum in which the program is discussed by and with responsible Corps coastal engineers. The presence of leading members of the coastal engineering community from outside the federal government on the Board relates the Corps' program to that of the overall community. CERC liaison representatives visit each coastal Division and District at least annually and discuss the program. Also, Division representatives are invited to technical program reviews conducted at CERC at the end of each year.

Continuing informal contact is maintained with Federal, state, and academic organizations involved in shore protection and restoration research. Particularly close relationships are maintained with key personnel in complementary research areas in various offices of NOAA. Joint projects are continually executed with other Federal and state agencies. A cooperative effort is under way with NOAA/NOS and the State of South Carolina to produce shoreline change maps. Another cooperative effort is under way to improve our ability to measure sediment concentrations in the field. The Chief, CERC, is the present Corps liaison representative to the Marine Board, National Research Council, National Academy of Engineering. This formal position is of immense benefit in assuring excellent coordination of this and other research programs in the Coastal Engineering Area with the industrial, academic, and Federal research communities. Lectures concerning this research program are given by the Chief and senior staff members of CERC at universities and at professional meetings throughout the United States (and worldwide when possible). Staff members of CERC are heavily involved in activities and programs of all pertinent professional societies. A number of staff members serve as members (or chairmen) of various technical committees of the various professional societies. The following table provides a summary of Shore Protection and Restoration Program funding.

SHORE PROTECTION AND RESTORATION PROGRAM

PROGRAM FUNDING SUMMARY

Relative Priority	Work Unit Number	Work Unit Title	Performing Laboratory	Prior Year	FY Funding Requirements - Thousand Dollars: CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	To Complete	TOTAL
1	31665	Barrier Island Sedimentation Studies	WES	2007	385	385	405	440	470	600	4692
2	31715	Lab and Scale Effects in Movable Bed Studies	WES	623	170	170	190	260	250	155	1818
3	31551	Numerical Modeling of Shoreline Response to Coastal Structures	WES	980	285	285	250	200	130	55	2185
4	32240	Regional Coastal Processes Numerical Modeling System	WES	285	250	250	275	250	225	25	1560
5	31181	Littoral Data Collection Methods and Their Engineering Application	WES	751	140	140	165	200	190	15	1601
6	31467	Storm Erosion Studies	WES	1045	90	90	90	10	0	0	1325
7	31235	Beachfill Sediment Criteria	WES	1914	145	145	190	230	220	225	3069
8	New	Three-Dimensional Simulation of Coastal Processes	WES	0	0	0	0	50	110	1290	1450
9	New	Guidelines for Sediment Budget Analyses	WES	0	0	0	0	40	100	1360	1500
10	New	Wave and Wind Generated Longshore Sediment Transport	WES	0	0	0	0	40	80	2480	2600
11	New	Cross-Shore Sediment Transport	WES	0	0	0	0	0	40	2685	2725
12	New	Characterization of the Surf Zone	WES	0	0	0	0	0	35	1655	1690
13	New	Beach Fill Sorting Techniques	WES	0	0	0	0	0	20	680	700
14	New	Effects of Submerged Barriers on Coastal Processes	WES	0	0	0	0	0	20	830	850
				7605	1465	1465	1565	1720	1890	12,055	27,765

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Barrier Island Sedimentation Studies
WORK UNIT NO. 31665	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$2007	$385	$385	$405	$440	$470	$600	$4,692

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop the capability to evaluate the long-term evolution of barrier islands and associated inlet and marsh systems using models of climatic-scale processes, and predict the geomorphic development of these areas. To assess the sediment budget along barrier island coasts, including sources and sinks of material, and determine sediment characteristics diagnostic of particular depositional environments. To design models of shore zone morphologic response to wave and storm conditions in the short-term, based on long-term trends in barrier system evolution and projections of sediment availability.

DESCRIPTION OF WORK: Existing theories of the origin and evolution of barrier islands, including tidal inlets, salt marshes, the shoreface and inner shelf regions, will be evaluated. Sediment samples will be collected from a variety of barrier island ecosystems. These will be analyzed to determine rates of development of depositional environments, their temporal and spatial variability, and classifications of process/response systems. This information will be used in conjunction with process data (sea level rise, wave climate, cyclone input, etc.) to develop a new series of time-dependent models of barrier island evolution and change. The models will be used to provide information and guidances for the management and protection of barriers and inlets in the most economical and effective way with the least adverse impact on natural environments and processes. Present methods for estimating sediment budgets along sandy coastlines will be refined.

R&D NEEDS: The present state of knowledge about barrier island systems and processes responsible for their origin, development, and maintenance is limited to generalized qualitative theory. R&D is needed to quantify these processes for prediction capability.

MILESTONES AND FORM OF OUTPUT

FY 85

Barrier Island Workshop
 - Nov 84
Shoreline Change TR
 Delmarva - Aug 85
 South Carolina - Oct 85*
Sea Level Effects TR - Aug 85
Sea Level Bibliography MP
 - Aug 85*
New Jersey Barriers TR
 - Sep 85
Gulf Coast Barriers TR
 - Sep 85
Nearshore Profile Variation
 TR - Aug 85*
Assateague Island TR - Sep 85
Shoreline Change Measurement
 CETN - Sep 85
FRF 85 Field Experiments
 - Sep 85
 Remote sampler development & testing high resolution sorting & structure
Field Guide to NC Morph. and Struct. MP - Aug 85

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-001-8	Guidelines to Establish a Coastal Sediment Budget	High
23-002-8	Guidelines for the Design and Construction of Beachfills	High
23-003-9	Shore Response to Offshore Dredging	High
23-004-9	Development of Modeling Techniques to Advance State-of-the-Art for Quantifying Hydraulic-Sediment Interaction	High
23-007-9	Economic Aspect of Grain Size on Beach Nourishment	High
23-002-9	Sand Recyclying or Nourishment Rates to Establish a Stable Shoreline	High
23-016-9	Erosion Due to Storms	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
1	31665	Barrier Island Sedimentation Studies

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$2007	$ 385	$ 385	$405	$440	$470	$600	$4,692

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	MISSION PROBLEMS ADDRESSED: NO.	TITLE	FIELD RANK
	FY 86 Shoreline Change TR: Florida - Sep 86* Georgia - Sep 86* Louisiana - Sep 86 * EM revision - Oct 85 EM 1110-2-3300 Core Banks Sedimentation TR - Aug 86 Sediment Sources TR - Sep 86 Duck 86 Field Experiment - Sep 86 3-dimensional sorting & transport processes FY 87 Shoreline Change Reports: GS- Dec 86: NY - Mar 87; TX - Jun 87; N. CA - Aug 87 Model of Sea Level Rise - Aug 87 FY 88 Shoreline Change Reports: Oregon - Dec 87 Washington - Mar 88. New England - Jun 88. Hawaii - Aug 88 Model of Barrier Island Evolution - Sep 88.			

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
ER 70-1-11

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 03 26

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
1	Barrier Island Sedimentation Studies
WORK UNIT NO	
31665	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY	BFY	+1	+2	+3	TO COMPLETE	TOTAL
	FY85	FY86	FY87	FY88	FY89		
$2007	$385	$385	$405	$440	$470	$600	$4,692

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT
	<u>To Complete</u> Shoreline Change Reports: Alaska Great Lakes Update Previous Maps Barrier Island Workshop * Completion dependent upon receipt of materials from other Federal and State agencies

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCW-P	85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
2	31715	Lab and Scale Effects in Movable Bed Studies

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$ 623	$ 170	$ 170	$ 190	$ 260	$ 250	$ 155	$1818

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

<u>OBJECTIVE:</u> To evaluate current state-of-the-art movable-bed modeling of coastal engineering projects and of basic laboratory studies of coastal phenomena involving movable-bed conditions; to define limits on model capabilities and to conduct and research program to improve modeling practice.

<u>DESCRIPTION OF WORK:</u> A literature review will be conducted and labs visited to determine the state-of-the-art and an expert panel convened to review the research program. Laboratory studies will then be conducted at CERC and WES. These studies will include modeling of onshore/offshore sediment motion at various scales to repeat previous prototype-sized sand tests run in the Large Wave Tank. This testing sequence will be used to determine how small the movable bed can be constructed and what effects the size of the model and sediment characteristics have on sediment motion. Similar tests will be performed with three-tests will be performed with three-dimensional models and the final effort of the project will be to model a specific site to test the model procedures developed in this project.

<u>R&D NEEDS:</u> Movable-bed tests are needed to economically plan and design many coastal projects. Basic laboratory studies of coastal phenomena involving movable-bed conditions also are important to advancing coastal engineering design capabilities. The Corps needs to improve its modeling techniques to enable more cost efficient design projects.

MILESTONES AND FORM OF OUTPUT

<u>FY 86</u>

Workshop on Modeling - Sep 86

<u>FY 87</u>

Report on Testing of Various Material used with Movable Bed Model - May 87

Final Report on 3-Dimensional Model - Mar 88

<u>FY 89</u>

Interim Report on Use of 3-D Models to Evaluate Coastal Protection Structures - Sep 89

<u>FY 90</u>

Final Report on Use of 3-D Models to Evaluate Coastal Protection Structures - Sep 90

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-002-8	Guidelines for the Design and Construction of Beach Fills	High
23-004-0	Estimating Alongshore Sand Movement from Incident Waves	High
23-005-9	Development of Modeling Technique to Advance State-of-the-Art for Quantifying Hydraulic-Sediment Interaction	High
23-007-9	Economic Aspect of Grain Size on Beach Nourishment	High
23-009-9	Littoral Transport Testing Procedures	High
21-007-9	Predicting Wave Conditions in Shallow Water	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
3	31551	Numerical Modeling of Shoreline Response to Coastal Structures

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$980	$285	$285	$250	$200	$130	$55	$2,185

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVES: To acquire and develop, as necessary, computer models capable of accurately predicting the shoreline response to a variety of coastal structures and natural events.

DESCRIPTION OF WORK: The effort will involve two phases. The first phase is devoted to the acquisition of existing models and those currently under development. The second phase will involve the research development, and testing of a state-of-the-art Numerical Sediment Transport Model (NSTM) that will satisfy the above objectives to a much greater extent than the less sophisticated models available at present.

R&D NEEDS: To date, the coastal engineering profession lacks a quantitatively accurate means of describing sediment transport in the nearshore region and especially the surf zone. It is of the utmost importance to acquire the ability to predict shoreline response to natural phenomena and man-made works if rational and economical methods for utilization of our coasts are ever to be developed. The benefits from this research will be realized through more accurate prediction of shoreline behavior, resulting in more economic design of coastal works. The end product will be a sophisticated computer model capable of use in site-specific design projects and the development of general design criteria.

MILESTONES AND FORM OF OUTPUT

FY 84

Technical Report on wave breaking and decay model - Sep 84

Field experiment on longshore transport - July - Oct 84.

FY 85

CETN on wave-induced current model - Mar 85.

Instructional Report on n-line model - Apr 85

Workshop on n-line model - May 85

FY 86

Report on research performed - Sep, 87

Duck '86 Experiment - Sep 86.

FY 87

Report on research performed - Sep 87

FY 88

Report on complete NSTM - Sep 88

FY 89

Report on testing and verification of NSTM -Sep 89

FY 90

Workshop for districts - Jan 90

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures on Shorelines.	High
23-002-8	Guidelines for the Design and Construction of Beachfills	High
23-003-9	Shore Response to Offshore Dredging	High
23-004-9	Estimating Alongshore Sand Movement from Incident Waves	High
23-005-9	Development of Modeling Techniques to Advance State-of-the-Art for Quantifying Hydraulic-Sediment Interaction	High
23-008-9	Seaward Limit of Significant Transport by Waves	High
23-016-9	Erosion Due to Storms	High
21-012-0	Nearshore Current Prediction	High
21-007-0	Predicting Wave Conditions in Shallow Water	High
21-010-0	Wave Setup	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY (ER 70-1-11)

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	TITLE
4	Regional Coastal Processes Numerical Modeling System
WORK UNIT NO	
32240	

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$285	$250	$250	$ 275	$250	$225	$25	$1,560

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: To develop a numerical modeling system that can predict coastal processes on a regional scale so that coastal changes resulting from natural forces and man-made structures and modifications (e.g., dredging and beach restoration) can be determined on a regional basis.

DESCRIPTION OF WORK: A numerical modeling system will be developed that simulates all of the important processes that determine coastal changes over a complete region. The modeling system will determine nearshore wave fields, wave-induced currents (littoral and rip currents), and wave-induced setup. In addition, tidal and storm surge currents and elevations also will be determined. The currents and wave fields will be used as forcing functions to drive sediment models that calculate alongshore and onshore-offshore sediment transport and transport due to tides and storm surge. Sediment input from sources such as rivers will be included. The modeling system will determine shoreline and coastal erosion and deposition, movement paths and the ultimate fate of coastal sediments, and effect of man-made structures and activities on coastal processes. The model will allow the evaluation of the effects a local project will have on a regional scale.

R&D NEEDS: The Corps of Engineers is involved in many activities (e.g., construction of structures, dredging, beach restoration projects) that impact coastal processes. Currently there are no reliable methods to determine impacts on a regional basis. Development of a regional coastal processes numerical modeling system will allow regional effects of projects to be determined once forcing functions (e.g., wave climate, sediment load from rivers) are established through a data measurement (continued)

MILESTONES AND FORM OF OUTPUT

Present Wave Refraction/ Diffraction Model at CERC Wave Modeling - Jan 85

Report on Wave Refraction/ Diffraction Model - Feb 85

Report on Regional Sediment Model - Sep 86

Report on Component Model Intergration - Feb 88

Computer Programs and Preliminary Instructional Manual for Operation of the Regional Coastal Processes Numerical Modeling System - Sep 88.

Workshop on Operation of Regional Coastal Processes Numerical Modeling System-Apr 89

Information Available for Engineering Manual on Regional Coastal Processes Studies - Sep 89.

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
24-005-9	Numerical Modeling to Evaluate Effects of Coastal Structures on Shorelines	High
23-001-8	Guidelines to Establish a Coastal Sediment Budget	High
23-016-9	Erosion Due to Storms	High
23-004-9	Evaluating Alongshore Sand Movement from Incident Waves	High
21-007-9	Predicting Wave Conditions in Shallow Water	High
21-020-9	Improvements and maintenance of Generalized Numerical Hydrodynamic Models	High
21-010-0	Wave Setup	High
21-012-0	Nearshore Current Prediction	High
22-008-9	Planning of Design Considerations for Deep Draft Navigation Channels	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCR-P	85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
4	32240	Regional Coastal Processes Numerical Modeling System

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$285	$250	$250	$275	$250	$225	$ 25	$1,560

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

program. The predictive power of the modeling system also will provide the basis for formulation of future local plans to reduce or prevent shoreline erosion, reduce maintenance dredging or stabilize inlets.

MILESTONES AND FORM OF OUTPUT

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

ENG FORM 4413-R, May 81 (Proponent: DAEN-RD) SHEET ___ OF ___

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCD-S	85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
5	31181	Littoral Data Collection Methods and Their Engineering Application

FY FUNDING REQUIREMENTS - THOUSAND DOLLARS

PRIOR YEARS	CFY FY85	BFY FY86	+1 FY87	+2 FY88	+3 FY89	TO COMPLETE	TOTAL
$ 751	$ 140	$ 140	$ 165	$200	$190	$15	$1601

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

<u>OBJECTIVE</u>: Develop new data collection and analysis techniques for visually and instrumentally obtained surf, longshore current, and sand transport data. Develop and refine methods of applying data collection results to the solution of sand bypassing and coastal structure design problems.

<u>DESCRIPTION OF WORK</u>: Research and development will be directed toward the further study and analysis of the basic field data described above to improve data collection techniques and analysis procedures. Efforts with the basic field data will include the evaluation and refinement of data collection techniques and analysis procedures, and the presentation of guidance for the application of data results to engineering problems (with emphasis on better production of sand transport rates and use of rate time sequence in coastal design).

<u>WHY R&D IS NEEDED</u>: Present methods of data collection and analysis do not refine salient features of coastal climate sufficiently for coastal engineering design purposes. Additionally, present design methodology does not address probabilistic nature of data collected. Benefits derived would be better estimates of sand transport for sand bypassing and coastal structure design, improved ability to ascertain project costs (by improved shoaling or accretion rates), and reduced structure costs due to better design.

MILESTONES AND FORM OF OUTPUT

Milestone	Date
MP Coastal Algorithms IV	Mar 85
CETN Sediment Transport	Apr 85
Revise LEO/CEIAC Sand Transport	May 85
Tech Paper, ETL - Sand Transport Distribution	Sep 85
Tech Paper, ETL - Statistics of Longshore Energy Flux	Aug 86
CETN - Directional Analysis	Sep 86
Tech Paper - Time Series Forecasting of Wave Statistics	Jun 87
CETN - Time Series Forecasting Techniques	Jun 88
TR, ETL - Time Series Analysis of Littoral Design Parameters	Sep 89

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-004-9	Estimating Alongshore Sand Movement from Incident Waves	High
23-006-9	Littoral Data Collection Methods and Their Engineering Application	High
23-017-2	Littoral Transport Measurements	High

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RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE: Shore Protection and Restoration		ORGANIZATIONAL SYMBOL: WESCR-P	DATE: 85 01 15

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY: 6	TITLE: STORM EROSION STUDIES
WORK UNIT NO.: 31467	

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY87	+2 FY	+3 FY	TO COMPLETE	TOTAL
$1045	$ 90	$90	$90	$ 10	$0	$ 0	$1325

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

Objective: The work unit objectives are to develop a capability to predict beach erosion, caused by storms and periods of high waves, and to define storm-induced nearshore profile changes.

Description of Work: Field measurements of storms and their effects collected at the FRF and at other beaches will be used to develop a simple empirical prediction of storm erosion and to evaluate existing profile response models.

Why R&D is Needed: Work unit results are needed by the Corps for predicting future storm erosion and for evaluating the maximum storm a beach of a given width could withstand when designing beach protection projects.

MILESTONES AND FORM OF OUTPUT

Publish Dutch Storm Erosion Prediction (Jun 85)

Publish Final Storm Erosion Data Report (Dec 85)

Publish Data Report on 4 Years of Nearshore Profiles (Aug 86)

Publish Report on Nearshore Profile Changes (Aug 87)

Duck '86 Experiment - Sep 86.

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-016-9	Erosion Due to Storms	High
23-002-8	Guidelines for the Design of Beachfills	High
23-005-9	Development of Modelling Techniques to Advance the State of the Art for Quantifying Hydraulic Sediment Interaction	High

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY

RCS: DAEN-RD-5

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCD-S	01 15 85

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
7	31235	Beach Fill Sediment Criteria

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY86	+1 FY87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 1914	$ 145	$ 145	$ 190	$ 230	$ 220	$ 225	$ 3069

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED

OBJECTIVE: Develop needed guidelines for the design of beach nourishment projects. Guidance will be provided for: locating, sampling, and selecting among alternative borrow sources; calculating fill requirements; and predicting project performance in terms of erosion and renourishment rates.

DESCRIPTION OF WORK: To permit collection of expensive, but essential field data, emphasis will be on cooperative work with districts that are planning and executing renourishment projects. Assistance can be provided in using the crude tools presently available; and through cooperative follow-up studies, data will be gathered to advance design criteria. *The goal will be to establish new design criteria that can* be applied with more economical testing of characteristics in the beach and nearshore areas. Interim products include new techniques for sampling and data interpretation. The final product will be a model to predict fill behavior and guidelines on how to select the best design, the most appropriate operational scheme, and the optimum fill material.

R&D NEEDS: A wide and high beach provides, in several senses, the best protection possible against erosion and flooding of backshore property. Artificial renourishment provides protection, but costs millions of dollars per mile. These costs are increasing, while the engineer needs guidance on how to design an economically effective beach fill project. The little guidance that is presently available is crude and untested. Until the performance characteristics of field projects are documented, no basis exists for establishing more comprehensive guidelines or even for determining the accuracy of those we have. Development of useful guidelines and models will simplify and shorten planning and improve performance. Cost savings can easily be 5 to 10 percent of the total present costs for beach fill projects.

MILESTONES AND FORM OF OUTPUT

Milestone	Date
Draft MP Improvement in Appearance of Dredged Material Subjected to Swash Action	Jul 85
Draft MP/ETL Adjusting Cumulative Frequency Data	Feb 86
Draft TR/ETL Procedures for Estimating Limiting Depth, Panama City, FL	Nov 86
Draft TR - Beach Sampling Techniques	Aug 87
Draft TR - Fill Performance Site I	Feb 88
Design Profile Seminar	May 88
Design Profile ETL	Jul 88
Draft TR/ETL - Design of Beach and Nearshore Sampling Plans	Dec 88

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK
23-002-8	Guidelines for the Design and Construction of Beach Fills	High
23-007-9	Economic Aspects of Grain Size on Beach Nourishment	High
ETL 1110-2-292	1983 Coastal Engineering Hydraulic Design Conference	

RESEARCH AND DEVELOPMENT PROGRAM SUMMARY
(ER 70-1-11)

RCS: DAEN-RD-6

PROGRAM TITLE	ORGANIZATIONAL SYMBOL	DATE
Shore Protection and Restoration	WESCD-S	01 15 85

FIVE YEAR RESEARCH PROGRAM WORK UNIT SUMMARY

PRIORITY	WORK UNIT NO	TITLE
7	31235	Beach Fill Sediment Criteria (Continued)

FY FUNDING REQUIREMENTS – THOUSAND DOLLARS

PRIOR YEARS	CFY FY 85	BFY FY 86	+1 FY 87	+2 FY 88	+3 FY 89	TO COMPLETE	TOTAL
$ 1914	$ 145	$ 145	$ 190	$ 230	$ 220	$ 225	$ 3069

OBJECTIVE, DESCRIPTION OF WORK AND WHY R&D IS NEEDED	MILESTONES AND FORM OF OUTPUT	
	Draft TR - New Approach for Determining on Site Envelope of Storm Erosion	Mar 89
	Draft TR - Geotechnical Criteria of Beach Fill	Jul 89
	Draft MP - Potential Applications of Numerical Modeling to Beach Fill Design	Dec 89
	Draft TR - Fill Performance Site II	Apr 90
	Draft TR - Beach and Borrow Area Sampling Guidelines	Jul 90
	Renourishment Design Manual	Nov 90
	Beach Fill Design Workshop	Mar 91

MISSION PROBLEMS ADDRESSED

NO.	TITLE	FIELD RANK

APPENDIX F

SUMMARY OF PRESENTATION BY

DR. JOSEPH N. SUHAYDA

THE NEED FOR NEW TECHNOLOGIES IN SOLVING TODAY'S COASTAL ENGINEERING PROBLEMS IN LOUISIANA

Dr. Joseph N. Suhayda
Associate Professor
Department of Civil Engineering
Louisiana State University

Louisiana currently faces a number of severe coastal engineering problems. These problems include the threat of coastal flooding, extreme rates of coastal erosion and land loss, and saltwater intrusion. At the same time Louisiana has one of the most heavily used and modified coastal zones in the world. Solving these engineering problems while continuing to use and develop the coast will require a high degree of scientific understanding and engineering skill. What is needed is new measurement techniques, predictive models, and structural designs which deal with the specific characteristics of this environment. This need is particularly evident in the processes involved in waves interacting with muddy bottom sediments.

Surface waves, the major source of energy in the coastal zone, cause bottom pressure fluctuations which can force an oscillation of muds to great depths below the mudline. Under extreme waves, bottom pressures of 1,000 psf will create shear stresses in muds as large as 350 psf, in many cases exceeding the shear strength of the muds. Mud oscillations can lead to massive submarine landslides and a major alteration to surface wave properties, such as velocity profiles, celerity, and height.

While the State of Louisiana has undertaken several steps to address the coastal problems, the development of sound coastal engineering methodologies which can be applied with confidence to the actual conditions in Louisiana will not be attempted. CERC, in cooperation with the State of Louisiana through the New Orleans District Office, would greatly benefit the state and the Nation if it were to support the development of such methodologies.

END

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